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Erica carnea from Curtis's Botanical Magazine

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On May 1, Dr. A. Orville Dahl will become Director of the Morris Arboretum, succeeding Dr. Fogg who has been Director since 1954. Dr. Fogg will remain on the staff as Director Emeritus and Taxonomist.

Dr. Dahl conducted his undergraduate and graduate studies at the University of Minnesota, where he received his doctor's degree in 1938. He has taught at Harvard (1938-1943) and at the University of Minnesota and except for intervals when he held research associateships in Sweden (1950-1951) and Denmark (1957-1958)

has been a member of the faculty of the latter institution since 1944.

From 1964 to 1966 Dr. Dahl was a Research Investigator at the University of Pennsylvania.

Dr. Dahl's principal research interests are in the fields of cytology, pollen morphology and atmospheric pollen. He developed the annual pollen count, which has been carried out for many years at Minnesota and is deeply involved in work with biosatellites, studies which lead into the most advanced areas of space biology. He possesses a wide acquaintance with plants and a keen interest in taxonomy.

(Continued on Page 21)

Heaths and Heathers in Eastern North America

BARBARA H. EMERSON

I. INTRODUCTION

Heather . . . the very word conjures up a vision of open countryside covered with a lovely haze of green and lavender. During closer association with heathers the constantly changing aspects that continuously appear are even more intriguing, especially to gardeners. Instead of becoming drab in winter, many heathers change foliage color to reds, gold, or an almost incredible pink. In nearly every season of the year at least one form of heather is in blossom, often producing the small white, pink, lavender, or purple flowers for several months. Habits vary from prostrate to erect, from compact to feathery, and from dwarf to arborescent. Vestiture may be woolly, silvery tomentose, or quite lacking.

"Heather" generally means *Calluna* Salisb., also called ling, the Scottish heather. Species of *Erica* L. are often referred to as heaths, although the terms heather and heath are interchangeable. Both genera belong to the Ericaceae or heath family which also includes *Rhododendron* L., *Gaultheria* L., *Arctostaphylos* Adans., and *Vaccinium* L. among its approximately 70 genera.

The sub-family Ericoideae constitutes a group of specialized plants whose xerophytic structure is an adaptation to living in bogs or moors where there is little air in the soil, or on mountains where the soil is often deficient in moisture. Ericoid leaves are typically thickened, needlelike, and revolute, reducing evaporation and trans-



Fig. 1. Bee pollinating and collecting nectar from *Erica carnea* 'Springwood White'



Fig. 2. *Erica carnea* 'Winter Beauty' (left foreground) and *E. carnea* 'Springwood White' (center) at Chatham, Massachusetts.

piration. The stomata are often protected from wind by a covering of hairs or by the grooves formed by rolled leaf margins. In *Calluna*, the leaves are so close that they overlap one another. Transpiration is further reduced by a tendency toward prostrate finely-branched growth habit. The wood is usually hard, dry, and brittle.

Like hollies, junipers, and certain other plant genera, heathers seem somewhat unstable genetically and produce progeny with myriad variations of habit, coloring, and behavior — all except the little spike-heath, which remains constant as a single species, *Bruckenthalia spiculifolia* (Salisb.) Reichenb.

This series of articles will be concerned with the primarily European species of the genus *Erica*, one of the two largest in the arbitrarily-chosen group. It will also discuss briefly the other less extensive northern genera, and finally consider the genus *Calluna* and some of its many cultivars.

If the characters of fused tubular corolla, superior ovary, and insect pollination (Fig. 1) are criteria of comparatively recent evolution, Ericads are not particularly ancient in origin. Geographically, ericas are unusual in that their distribution is longitudinal, being limited to Europe, Asia Minor, and Africa. This somewhat parallels the longitudinal restriction of Cactaceae and most Polemoniaceae to the New World hemisphere.

There is a great concentration of 630 species of *Erica* in South Africa. Most are unique to the Cape Colony. One erica, *E. arborea* L., occurs in Ethiopia and is commonly found along the northern edge of Africa, as are *E. multiflora* L. and *E. scoparia* L. These two, like four other species (*E. umbellata* L., *E. terminalis* Salisb., *E. australis* L. and *E. ciliaris* L.) from the northernmost tip of Morocco also appear in southern Europe, often growing with boreal species such as *E. Tetralix* L. and *E. vagans* L. The latter ranges only to the Lizard in Cornwall, but *E. Tetralix* can be found in bogs, moors, and wet heaths throughout Great Britain, along the western coast of Europe, and northward along the Scandinavian coast as far as Lapland.

The taxonomic basis for the geographic distribution of *Erica* has not yet been completed although it has been determined for the African Ericoideae *Philippia* Klot. and *Blaeria* L., and Dulfer (1965) has completed a study of the South African *Erica* species. There seem to be three or four major possibilities concerning the origin and distribution of *Erica*. The beginning of the first theory can be traced to von Ettinghausen, the phytopaleontologist who discovered in Europe Proteaceae and other fossils of plants which are now solely South African. This theory assumes that the Northern hemisphere was the starting point of all flora, and Europe a primary development center.

K. H. H. Christ maintained that certain Ericoideae immigrated into Europe from the Cape of Good Hope during the Tertiary. Engler thought he could prove that tropical mountainous East Africa was the point of Ericoideae origin, but later accepted Christ's theory. However, a meticulous analysis by Hansen (1950) indicated that neither theory could be brought into agreement with the distribution characteristics of *Erica*. She concluded that the close



Fig. 3. Twelve-year-old heather plants cultivated near Reading, Vermont.



Fig. 4. Heathers at the Morris Arboretum in September, 1966

morphological relationship between some of the European and South African *Erica* sections shows that European and Cape species must have become isolated fairly recently. During the Tertiary there was probably a connection between them which she believed can still be found in certain locations in the eastern Mediterranean area, Ethiopia, East African mountains, and South Africa.

After examining the seven Ericoideae genera, Hansen partially corroborated Engler's views. She decided that the Ericoideae must have originated close to Madagascar, and that East Africa might be the southernmost portion of a much larger development region. If this is so, the primary center of Ericoideae development might well be considered as the entire southeastern Mediterranean area across Ethiopia into tropical East Africa. Starting from there, *Calluna* is presumed to have emigrated toward the northwest, and the Atlantic *Erica* genera toward the western European mountains and farther north to the western European coast. There, species such as *E. Tetralix*, *E. ciliaris*, and *E. cinerea* L. are now common. *Erica carnea* L. may have moved northward to the Alps, and *Bruckenthalia* northeast to the Transylvanian mountains in Roumania.

Erica terminalis, *E. australis*, *E. verticillata* Forsk., *E. arborea*, and *E. scoparia*, which are ecologically less specialized or more adapted to arid conditions, remained in the Mediterranean region in relic locations or spread, as must be assumed of *E. arborea* and *E. scoparia*.

The extensive development of ericas at the Cape of Good Hope indicates they must have reached that area at an early date. If one accepts the theory of North-South movement of climatic zones and vegetation belts caused by polar wandering and shifting of the Equator from its late Cretaceous location in Europe to its present

location in Africa, it is plausible to consider the Mediterranean region as the early Tertiary center from which Ericoideae went north as well as southeast. Like other genera, the ericas in the Mediterranean region today are only relics of a formerly more widespread population.

Coats (1964) cited Dioscorides' description of heather as the first ever recorded. Translated by Turner, "Irica, sayth Dioscorides, is a busshy tre lyke unto Tamariske, but much lesse, of whose floures bees make noughty honey". Linnaeus' classification of the genus included *Erica vulgaris* L. Salisbury recognized the plant as a distinct monotypic genus, now properly designated as *Calluna vulgaris* (L.) Hull.

Ericas and *Calluna* have long been known and utilized in the regions where they occur naturally. Heathlands have provided grazing for sheep, deer, and grouse, and nectar for a distinctive honey. Domestically, heaths have been used for thatch, rope, bedding, and brooms. Heather is the national flower of Scotland, and the white form is affectionately regarded as a purveyor of good fortune, but there is little evidence that heathers were used horticulturally until rather recently. Andrews (1802) listed in his preface to *The Heathery* the native *E. vulgaris*¹, *E. Tetralix*, *E. cinerea*, *E. vagans*, and the Irish *E. Daboecii* L.¹ *Erica arborea* was introduced from Madeira in 1748; *E. herbacea* L.¹ from Switzerland in 1763; *E. mediterranea* L. from Minorca in 1765; and between 1768 and 1770 *E. scoparia*, *E. viridi purpurea* L.¹, *E. australis*, *E. ciliaris*, and *E. umbellata* from Portugal. *Erica stricta* Donn¹ and *E. multiflora* were not brought from Spain until 1790. In the meantime, what was to become a tremendous influx of species from the

¹ Now properly named *Calluna vulgaris*, *Daboecia cantabrica* (L.) Koch., *E. carneae*, *E. lusitanica* Rudolph, *E. terminalis* Salisb. and *E. concinna* Soland., respectively.



Fig. 5. *Erica carneae* 'King George'



Fig. 6. *Erica mediterranea* 'W. T. Rackliff'

Cape of Good Hope had begun when seed of two species, *Erica tubiflora* Willd. and *E. abietina* Andr. ex G. Don¹ arrived in 1771. Within fifty years, several hundred of these beautiful tender South African species had been imported in spite of the fact that they were often difficult to grow even under glass. It became fashionable to assemble large collections of them. Andrews had illustrated nearly three hundred in a series of four folio volumes by 1830. J. C. Wendland, who prepared *Ericarum Icones et Descriptiones*, described 151 species in Hannover in 1804. The Empress Josephine imported large numbers of heaths for her gardens at Malmaison. Interest in the more familiar European species was stimulated, and gardeners began heather plantings outdoors with their hardy shrubs. Enthusiasm for the Cape heaths waned toward the end of the nineteenth century, but the popularity of the harder forms has increased, especially since the early part of the present century, as their many charms and horticultural virtues have become recognized.

Many heath-fanciers search the moors and heaths for unusual forms of *Erica* and *Calluna*. These have frequently been named, propagated, introduced, and sold by nurseries. As far as I have been able to ascertain, there has been very little deliberate heather breeding, new cultivars being chance finds by careful observers, whether in open country or nursery beds.

Since the first published account in 1850, there have been numerous instances of discovering uncultivated heathers in North America. Clarkson (1958) listed twenty-nine localities for *Calluna vulgaris*, six for *Erica Tetralix*, and on Nantucket Island one each for *E. cinerea* and

E. vagans. Fernald (1950) included Michigan in the range for *Calluna* and Beijerinck (1940) wrote of it "near Marquette (Michigan)" and purportedly from Mexico, although the latter seems doubtful.

These discoveries excited great botanical interest and controversy. However, tempting as some accounts seem, careful study leads one to conclude that neither the ericas nor *Calluna* are North American natives. In many cases, such as the several stations described by Owen (1908), the mode of introduction is known or can easily be surmised. Heather is not plentiful at any North American site, in spite of early reports that it covered vast areas. All stations, including the most recent discovery in the mountains of West Virginia, appear to be associated with human habitation. The heather bedding of Scottish or Irish settlers, Highland soldiers' heather brooms, inadvertent planting with trees shipped from England, and attempts to induce heather to purple the hills of Nantucket can



Fig. 8. *Erica* × 'Darleyensis'

explain many colonies of heather. There is even a possibility that some *Calluna* may have been transported by Vikings. Although for many years Asa Gray considered it a native, and Fernald's explorations (1926) to determine its true status were not as extensive as planned, by the time the latter prepared the Eighth Edition of Gray's Manual of Botany (1950) he had clearly decided that *Calluna* and the ericas are naturalized introductions.

Hardy heathers and heaths, then, are known to have been growing wild in North America for nearly 140 years. It is hard to know how long they have been cultivated in gardens. Many sentimental housewives must have brought heather clippings to their new homes when they came to America. Today, the greatest number of *Erica* species (but not of heather cultivars) is found along the Pacific coast whose climatic conditions resemble those of the Old World where these genera are native. In California and Southern California some Cape heaths are grown. Northward, there are good representations of the hardier heather species and cultivars in nurseries and gardens in Oregon, Washington, and British Columbia.

Many heathers appear more adaptable than was formerly thought. Both *Calluna vulgaris* and *Erica carnea* have been seen surviving in as unlikely a location as Detroit, Michigan. In the East, heathers are being cultivated from North Carolina to near the Canadian border of Vermont. The optimum conditions for heather culture seem to prevail on Cape Cod at Chatham, Massachusetts, where Copeland (1965) has assembled an impressive collection. (Fig. 2) His goal, which is very close to realization, is to acquire for American gardeners all the species and



Fig. 7. *Erica mediterranea*

cultivars that might be expected to grow in this country. There are other good heather gardens in the vicinity of Philadelphia, Pennsylvania, and in New York State, especially on Long Island. Less extensive plantings have persisted for several years through rigorous winters in Batavia, New York, and Reading, Vermont, (Fig. 3) as well as at many intermediate locations. Unfortunately, the lovely Reef Point Gardens of Bar Harbor, Maine, no longer exist, but forty heather forms grew well there in 1954.

The interest of the Morris Arboretum in developing a Heath Garden which would include forms of *Erica* and *Calluna* among its wide representation of Ericaceae has already been described (Fogg, 1966). That *Erica* is not new to the Arboretum grounds is evidenced by the presence of a herbarium specimen made in 1932, the year the University of Pennsylvania began direction of the property bequeathed to it by the Morrises. The specimen is from a plant of *Erica vagans* described as being five feet in diameter.

The nucleus of the present collection of heathers was acquired through the interest and efforts of Mrs. Alfred S. Martin (née Mary O. Milton) while she was the Arboretum's Propagator (Martin, 1964). Expansion of the Arboretum collection continued under the direction of Dr. John M. Fogg, Director of the Morris Arboretum, and Superintendent John Dourley, who constructed the present Heath Garden. (Fig. 4) It was at this stage that I had the considerable privilege and pleasure of becoming active in the project.

Longwood Gardens in Kennett Square, Pennsylvania, has a fine display of many heathers. Several other institutions in the Northeast have small collections, but none conduct serious horticultural or botanical heather research in the



Fig. 9. Pheasant nest and eggs in *Erica* × 'Darleyensis'



Fig. 10. *Erica carnea* 'Winter Beauty' November 17, 1966

East. It was concluded that this was a service the Morris Arboretum could undertake. Accumulation of a good collection was intensified with several purposes in mind. Since one obvious and functional objective was that of becoming an authoritative center of information concerning hardy heathers, pertinent literature references and commercial plant sources were sought. An inclusive list of cultivar names was started. Many gardens and nurseries in the northeastern states were visited, and representative herbarium specimens were made for reference and study, as they will continue to be. This is supplemented by color transparencies for lecture and other purposes.

Most important, while giving visitors great pleasure, the steadily-increasing collection of plants is being studied in many ways. Relatively little is known of the comparative effects of different climatic conditions on heathers. Those grown in North America near a latitude of 40° may behave somewhat differently than those grown in Great Britain and nearby countries at latitudes of 50 to 65°, where day length and light intensity are different. Greater fluctuation of temperatures and differences in atmospheric as well as soil moisture in eastern North America must undoubtedly exert an influence on the growth of heathers.

At regular intervals, changes in the Arboretum's heathers are observed and recorded. Plants are compared to decide questions of apparent duplication under different cultivar names. Colors are being described from the Nickerson Color Fan, which is based on the numerical Munsell color system and is distributed by The American Horticultural Society, 1600 Bladensburg Road, N.E., Washington, D.C. 20002. This fan was chosen as a standard because its quality is acceptable, it is readily obtainable, and it is convenient to use. There is variation in the

coloring of a single heather flower, between flowers receiving different intensities of light at different positions on a plant, and between flowers at different stages of maturity. Therefore it is not reasonable to attempt an exact match, but a close approximation of hue and intensity is being determined for flowers and foliage of each species and cultivar being grown. It is now obvious that the range of their floral hues is quite narrow. All the heather flowers examined have exhibited different values of purplish pinks or reds, or reddish purples. None appear even close to yellow-reds; flowers often described as salmon, terra cotta, or "having not a hint of blue" all prove to be blue-reds.

Anthocyanin pigments, often helpful in taxonomic determinations, were extracted from suitable forms of *Calluna* and several ericas, and were analyzed by paper chromatography. An account of this investigation conducted by Dr. Frank S. Santamour and Rudolph A. Lucente of the Arboretum staff can be found on pages 12 to 13 of this issue of the Bulletin.

The Morris Arboretum collection of heathers now contains 78 cultivars of *Calluna vulgaris*, 14 *Erica* species, and 98 *Erica* cultivars. Beside *Calluna vulgaris*, *Erica arborea*, *E. australis*, *E. carnea*, *E. ciliaris*, *E. cinerea*, *E. Mackiana* Bab., *E. mediterranea*, *E. scoparia*, *E. terminalis*, *E. Tetralix*, and *E. vagans*, and several hybrids such as *E. × 'Darleyensis'*, *E. × 'Dawn'*, *E. × 'Stuartii'*, *E. × 'Watsonii'*, and *E. × 'Williamsii'* are included. *Bruckenthalia spiculifolia* and forms of *Daboecia cantabrica* are also being grown, as well as the many other Ericaceous genera already enumerated (Fogg, 1966).

II. WINTER-FLOWERING ERICA FORMS

There is some question as to the proper classification and nomenclature of the winter-flowering forms of *Erica*. For the present, we shall use



Fig. 11. *Erica carnea* 'Winter Beauty' January 3, 1965

the common designations of *Erica carnea*, *E. mediterranea*, and *E. × 'Darleyensis'*. All three can be distinguished from other European *Erica* species by the combination of glabrous leaves and sepals, exserted anthers without appendages, axillary flowers in terminal one-sided racemes, and sepals more than half as long as the ovoid corolla.

Bentham considered *E. mediterranea* to be only an ecological form of *E. carnea*, but this is not now generally thought to be the case. *Erica carnea* is a decumbent, more or less creeping shrub, seldom growing more than 0.3 m. tall. The flowers are produced from early winter until mid- to late spring, and have exserted anthers. (Fig. 5) *Erica mediterranea* grows upright to a height of two to ten feet, depending on the geographical location. Its anthers are only partially exserted. The flowers, which are smaller and somewhat broader than those typical of *E. carnea*, appear later and for a shorter time, usually from late winter until mid-spring. (Figs. 6, 7) Beside these distinctions, Borja Carbonell (1954) also pointed out the significant differences in geographic distribution and ecological associations, and that while *E. carnea* is odorless, *E. mediterranea* has a honey-like fragrance that persists for a long time even in dried herbarium material. This statement was tested and found to be true of specimens 100 years old, indicating a chemical difference between the two entities.

Erica × 'Darleyensis' was found as a sturdy seedling in the nursery of James Smith & Son in Darley Dale, Derbyshire, England, in 1898, and assumed to be a hybrid between *E. carnea* and *E. mediterranea*. It has characteristics of both species, and also exhibits hybrid vigor. (Fig. 8) Introduced as *Erica mediterranea hybrida*, it was renamed by Bean because the epithet *hybrida* had already been given to a Cape heath. *Erica hybrida darleyensis* is another name used commonly in nursery lists, but it, too, is illegitimate for the same reason. Regardless of its name, plants of it in the Heath Garden have become so well established that a pheasant made a nest and laid her eggs in a clump of *E. × 'Darleyensis'* in 1966. (Fig. 9)

Philip Miller (1759) was probably the first writer to suggest that heathers native to Great Britain be considered for cultivation in gardens. Four years later George William, Earl of Coventry, introduced *Erica carnea* from its Alpine habitat. It is the one winter-hardy species not native to the British Isles, and is known as the winter, mountain, or Alpine forest heath. Its horticultural value was quickly recognized, and this winter-flowering species was the eleventh to be illustrated (in 1787) in the first volume of



Fig. 12. Winter stem injury, *Erica carnea*
'Winter Beauty' February 21, 1965

Curtis's Botanical Magazine. (See Cover) Even at this early date, only forty years after the publication of Linnaeus' Species Plantarum, there were nomenclatural difficulties which continue to plague botanists and horticulturists today. Curtis, a gardener rather than a botanist, conceived his magazine to be "a work in which Botany and Gardening . . . or the labour of Linnaeus and Miller, might happily be combined". In spite of this, the engraving which clearly depicts *Erica carnea* is presented as *E. herbacea* L. The latter is the third, and *E. carnea* the sixteenth, of twenty-three species of *Erica* Linnaeus described in the 1753 edition of Species Plantarum. The brief descriptions to which he limited himself raised questions of identity which were partially answered by examining the microfilms of the Linnaean Society's holdings of Linnaeus' herbarium specimens.² One of the two *E. herbacea* sheets bears no inscription, but on the other, noted in Linnaeus' handwriting, is a later determination as *Empetrum*, which both specimens appear to be, and not *Erica* at all. There may have been further discussion of the matter in Dahlgren's *Dissertatio de Erica* (1770), which is not available to us at the present time but will be considered later.

The geographic distribution of *Erica carnea* is irregular, with habitats in the central and eastern Alps from northwest Italy through Switzerland to lower Germany and Austria. Toward the

south, it occurs through Tuscany to Rome and in central Albania. The mountain heath seems indifferent to variations in altitude, growing from the plains to subalpine mountain regions near the timberline. Hansen considered *Erica carnea* to be Mediterranean in origin, coming northward to the Alpine areas during the Tertiary. She assumed that the present areas in the north are only parts of a larger total area which was glaciated, and that the mountains of upper Italy and the Balkans are refuges from which new habitats have been established, such as long the Alpine rivers into the plains.

Erica mediterranea although similar to *E. carnea* has an entirely different geographic distribution. In spite of its commonly-used name, it occurs mainly in northwestern Portugal, in Spain around Valencia, in a small section of the western coast of France, and also in western Ireland (the counties of Mayo, Galway, and Connemara).

Chance seeding from heather-packed shipments of Spanish wine is a delightful and perhaps valid explanation for the occurrence of *Erica mediterranea* in Ireland. However, several other plant and animal species have about the same disjunct distribution, and puzzled biologists have searched for a more comprehensive answer. Godwin (1956) studied the evidence and felt that spread by wind or birds is improbable. Even though some parts of Ireland were not covered by ice in recent glaciation, survival in adjacent areas of plants unable to tolerate extreme cold is unlikely. Instead, apparently these species migrated northward to Ireland at a time when the climate was favorable and the coastline continuous in a way which it now is not.

The hypothesis that southern species were able to enter Ireland when the sea-level was much lower and there were probably land bridges between Great Britain and the Continent seems logical. Fossil evidence of *Erica Mackaiana* Bab. recognized by Jessen established its early presence in County Galway. Other discoveries confirmed that by the Preboreal period, conditions in the British Isles were open for the invasion of markedly southern species. Godwin concluded, "Given the facts of the establishment of southern species . . . and approximate dimensions and date of sea-level restoration, it does not seem impossible that the greater part of the Lusitanian-Mediterranean element should have reached England and Ireland by coastwise migration during the early Post-glacial period. The extremely oceanic climate has permitted juxtapositions and overlaps of range quite unfamiliar in other lands, so that arctic-alpine and Mediterranean species now

² An enlightening paper on the nomenclature of European *Erica* species by Dr. R. Ross, Curator of the Eastern European Section of the British Museum, was received when the present issue of the Morris Arboretum Bulletin was already in press. Discussion of Dr. Ross's findings and clarification of several problems of proper designation will be incorporated in the next part of this article, in the June issue of the Bulletin.

meet on the western Irish coast, the one escaping high summer temperatures and drought, the latter escaping winter frosts. . . The positive evidence of the early spread of the Hiberno-Lusitanian-Mediterranean plants is still to seek, but there seems no reason why persistent search should not now reveal it."

Among plants, flowering throughout the winter and early spring months, indeed unique, is exhibited to a marked degree by forms of *Erica carnea* and *E. × Darleyensis* and only slightly less by *E. mediterranea* and its cultivars. These heathers have the precocious habit of forming in early summer conspicuous flower buds which do not mature until many months later. British writers refer to *Erica carnea* bud-set in July or August, and flowering from December until April. Under Philadelphia conditions, flower buds are evident by June or July. Some cultivars reach anthesis in October or early November (Fig. 10), with the peak of blossoming in mid-April. A few continue flowering until the end of May, so the last of the current season's sexual development nearly overlaps that of the year to follow. *Erica × Darleyensis* and its cultivars behave essentially the same way as *E. carnea*. Forms of *E. mediterranea* flower somewhat later; their buds have not become conspicuous until December, and they have finished flowering by late April or May.

Because ericas are mycorrhizal, having no root hairs to absorb nutrients, the presence of humus in the soil is essential to their growth. However, *Erica carnea* seems adaptable to a variety of soils. It grows in those with high mineral content, and tolerates but does not require acidity.

Cold tolerance is a complex and variable quality. *Erica carnea* continues flowering under snow and ice. (Fig. 11) British and German horticulturists refer to this species as completely winter hardy, but this is not entirely true in northeastern United States. Plants in Vermont are usually covered with snow during the winter when sub-zero temperatures prevail, and are thus protected from cold. A few gnarled specimens have persisted in an old untended heather garden on Nantucket. Copeland protects newly-set heathers with a mulch of cranberry vines (*Vaccinium macrocarpum* Ait.) but has never observed winter damage to any of his unprotected established plants on Cape Cod with the open Atlantic Ocean at the edge of his property. Climatic conditions are similar on nearby Long Island, but the late Esther Deutsch found it advisable to protect all her heathers with a mulch of salt marsh hay. The same thing is true at the western end of Cape Cod, in Falmouth, where H. V. Lawrence Company applies cran-



Fig. 13. *Erica carnea* from Curius's Botanical Magazine, Vol. 1, 1793

berry vines for protection. Unprotected *Erica carnea* at the Morris Arboretum endured a temperature drop to 15° F. in December with no apparent injury. However, in January when light intensity is greater and leaf surface temperatures higher, sub-freezing air sometimes causes injury. Damage may be evident as stem splitting, older stems appearing so shredded that one suspects an explosion has occurred. (Fig. 12) Normal vegetative development continues even on stems that have been reduced to half or less of their original diameter, so the aesthetic value of the snow heath in the garden is not diminished.

After the initial formation of flowers, which is terminal, most branching is lateral. In established plants, branch renewal is from the uppermost lateral shoots. Both terminal and axillary blossom shoots occur, with flowers opening at the tip first. Calyxes and corollas remain greenish in bud, whether through the prolonged period of summer and fall, or the shorter spring develop-

ment time. The more conspicuous pigmentation of both structures becomes evident as the flowers reach anthesis. The onset of flowering varies somewhat between cultivars, *Erica carnea* 'Praecox Rubra' commencing in October, *E. carnea* 'C. J. Backhouse' and 'Winter Beauty' in November, most other cultivars in January, and a few (notably *E. carnea* 'Sherwoodii' and 'Vivellii') not until February or later.

The Morris Arboretum now lists twenty-five cultivars of *Erica carnea*, eight of *E. mediterranea*, and five *Erica carnea* × *E. mediterranea* hybrids in its collection of winter-flowering ericas. The *E. carnea* cultivars are 'Aurea', 'Carnea', 'Cecelia M. Beale', 'C. J. Backhouse', 'Eileen Porter', 'Gracilis', 'Heathwood', 'James Backhouse', 'King George', 'Mrs. Sam Doncaster', 'Pink Beauty', 'Praecox Rubra', 'Queen Mary', 'Queen of Spain', 'Rosy Gem', 'Rubra', 'Ruby Glow', 'Sherwoodii', 'Snow Queen', 'Springwood Pink', 'Springwood White', 'Thomas Kingscote', 'Vivellii', 'White Glory', and 'Winter Beauty'. *Erica mediterranea* and its cultivars ('Alba', 'Brightness', 'Hibernica', 'Maxima', 'Nana', 'Silberschmelz', 'Superba', and 'W. T. Rackliff') show pronounced leaf and stem burn after severe cold in late winter, but not in early winter. *Erica* × 'Darleyensis' and cultivars which are presumed to have similar parentage ('Arthur Johnson', 'Cherry Stevens', 'George Rendall', and 'N. R. Webster') are more tolerant of cold.

These forms, like most other heathers being grown in America, are so well described in recent British and German publications (Chappel, 1964; Maxwell and Patrick, 1966; Hondelmann, 1956) that there seems to be little point in repeating such material here at the present time. Chappel (1966) has also published a detailed account of the introduction of most cultivars of the winter-flowering ericas.

Interest in growing heaths in the garden was greatly stimulated by James Backhouse's introduction of fourteen excellent *Erica carnea* cultivars many years ago. Unfortunately, identities of these forms became confused, and knowledgeable growers think it is no longer possible to distinguish and name many of them properly. Ten of these are in the Morris Arboretum collection: *E. carnea* 'C. J. Backhouse', 'Gracilis',

'James Backhouse', 'King George', 'Mrs. Sam Doncaster', 'Praecox Rubra', 'Queen Mary', 'Queen of Spain', 'Thomas Kingscote', and 'Winter Beauty'.

Erica carnea 'Sherwoodii' originated at Sherwood Nursery Co., in Corbett, Oregon, and is particularly distinguished by vigorous open stem growth, prostrate habit, slightly yellow-green foliage, larger corolla, and sepals somewhat more reflexed than other forms. The color of both corolla and calyx is strong reddish purple (2.5 RP 5/10 on the Nickerson Color Fan).

(To be continued)

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Anthocyanins in the Ericaceae

FRANK S. SANTAMOUR, JR. AND RUDOLPH A. LUCENTE¹

Past studies of anthocyanin pigmentation in the Ericaceae (Heath family) have been largely restricted to the genus *Rhododendron*. Harborne (1962) examined the flowers of 83 species of *Rhododendron* and also summarized earlier work on this genus. In red-flowered species, such as *R. Thomsonii* Hook. f., he found equal amounts of cyanidin 3-galactoside and cyanidin 3-arabinoside. Purple-flowered species, such as *R. ponticum* L., contained malvidin 3, 5-diglucoside. Hydrolysis of petal extracts of more than 40 species gave delphinidin and petunidin in addition to cyanidin and malvidin, but no further elucidation of the glycosidic types was attempted. In another summary (Harborne, 1963), the 3-galactosides of cyanidin, peonidin, and malvidin were reported from the berries of *Vaccinium* spp.

About one-half of the 83 *Rhododendron* species examined by Harborne also contained the unusual flavonol glycoside azalein, which gives a blue fluorescence in ultraviolet light. Azalein has been found only in the Ericaceae and in *Plumbago capensis* of the Plumbaginaceae.

The Morris Arboretum has recently established a Heath Garden, containing many cultivars of *Erica*, *Calluna*, and other genera which are less well known than *Rhododendron*. Inasmuch as many of the differences between cultivars are based on rather vague differences in flower color, a study was initiated to determine the pigment types in the two major heath genera. Flowers and foliage of other ericaceous plants were also included to broaden the study.

MATERIAL AND METHODS

Anthocyanins were extracted from the various tissues in cold 1% methanolic HCl. Paper chromatography of the extracts was performed by the ascending technique on Whatman No. 1 or 3 MM paper, with BAW and 1% HCl as the primary solvents. Hydrolyzed extracts were run in Forestal solvent. Pigments were purified by repeated chromatography and, after elution, their absorption spectra were examined using a Bausch & Lomb Spectronic '20' spectrophotometer. Details as to the procedures used are given in previous papers (Santamour, 1965 a,b).

¹ Research Assistant under a grant from the Michaux Fund of the American Philosophical Society.

It soon became apparent that, in *Erica*, the bulk of the material contained a single anthocyanin, a cyanidin 3-monoside. The primary question was whether the sugar moiety was glucose, the most common sugar in anthocyanins, or galactose, as had been found in *Rhododendron*.

According to established standards (Harborne, 1958), cyanidin 3-glucoside and cyanidin 3-galactoside have nearly identical R_f values in a variety of solvents. We extracted cyanidin 3-galactoside from red apple skins and although the apple anthocyanin had a lower R_f than that from *Erica* when run individually on the same chromatogram, co-chromatography of a mixture of extracts showed no separation. Extraction and identification of the sugars following hydrolysis was likewise unsatisfactory under our conditions.

However, the common occurrence of the same sugars in anthocyanins and flavonols of the same plant provided a means of possible identification. The R_f values of quercetin 3-glucoside and quercetin 3-galactoside are sufficiently different in BAW and distilled water so that they can be separated by two-dimensional chromatography. In this way the primary flavonol of *Erica* flowers was determined to be quercetin 3-glucoside and the most common anthocyanin is assumed to be cyanidin 3-glucoside. The presence of a cyanidin 3, 5-diglycoside in flowers of another *Erica* species strengthens this assumption.

This type of analysis was undertaken only for *Erica*, and there may be more doubt as to the sugar moiety in other genera where the anthocyanin has been identified as cyanidin 3-glucoside.

RESULTS

Azalein was not found in any of the species discussed below:

Erica

Cyanidin 3-glucoside (R_f 0.37, 0.07)² was determined to be the only anthocyanin present in flowers of the following: *E. carnea* L.; *E. Mackiana* Bab., *E. terminalis* Salisb.; *E. Tetralix* L. 'Con Underwood', 'E. Tetralix', 'Rubra', and *E. Darleyensis*; *E. vagans* L. 'Cevennes' and *E. vagans* 'Mrs. D. F. Maxwell'; *E. × Watsonii* Bab. and *E. × Dawn* (*E. ciliaris* × *Tetralix*); and *E. × Williamsii* Druce (*E. Tetralix* × *vagans*).

² R_f values in BAW and 1% HCl.

The early, pigmented foliage of *E. cinerea* L. 'Golden Drop' also contained only cyanidin 3-glucoside. However, the flowers of five other cultivars of this species ('Mrs. Ford', 'C. D. Eason', 'Splendens,' 'P. S. Patrick' and 'Atrosanguinea') contained both the monoglucoside and the 3,5-diglucoside of cyanidin (R_f 0.27, 0.20)². Hydrolyzed foliage of 'Golden Drop' gave both cyanidin and delphinidin, indicating the presence of leucodelphinidin.

Calluna

The flowers of several cultivars of *Calluna vulgaris* (L.) Hull, including 'Tenuis', 'J. H. Hamilton', 'Floreplena', 'County Wicklow', and 'H. E. Beale' contained a single anthocyanin, assumed to be cyanidin 3-glucoside. Pigmented foliage of *C. vulgaris* 'Cuprea' and *C. vulgaris* 'Mrs. Pat' gave the same anthocyanin, and hydrolysis of the foliage indicated the presence of leucodelphinidin, as in *Erica*.

Oxydendrum

The anthocyanin pigment involved in the autumnal coloration of the leaves of *Oxydendrum arboreum* (L.) DC. or sorrel-tree was identified as cyanidin 3-arabinoside. This pigment had an R_f of 0.44 in BAW, 0.31 in Bu HCl, and 0.07 in 1% HCl; maximum absorption was at 528 mu.

Other species

A cyanidin 3-monoside, probably glucoside, was the only anthocyanin found in flowers of *Bruckenthalia spiculifolia* (Salisb.) Reichenb. and *Kalmia angustifolia* L. as well as in young, highly-pigmented leaves of *Pieris japonica* (Thunb.) D. Don.

DISCUSSION

The anthocyanin pigments of flowers of *Erica* and *Calluna* have been shown to be identical within a species and also among many species and hybrids. Such variation in color as does

occur may depend on pigment concentration, modifying chemicals, or environmental factors. It is likely that the influence of the environment, particularly in regard to soil acidity, may play a major role in situations where certain cultivars do not exhibit the quality of color described at the time of their original selection. With the limited array of pigments available in the species studied, the breeder cannot expect to create much variation on the color theme. It might be possible, however, to develop a bluer flower in *E. cinerea*, since cyanidin 3, 5-diglucoside may be co-pigmented with other flavonoids to give a blue color.

To the best of our knowledge, the discovery of cyanidin 3-arabinoside in *Oxydendrum* is the first report of this anthocyanin as the major pigment in autumnal leaf coloration. Cyanidin 3-glucoside is by far the most prevalent pigment in fall-colored leaves.

ACKNOWLEDGMENT

We wish to thank Mrs. Mark F. Emerson who, as the guiding force behind the Heath Garden, served as instigator and collaborator in this project.

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The Dodders—Green Plants That Would Be Fungi

PATRICIA ALLISON

There are abundant examples of so-called mimicry in the living world, especially among the insects. Some of them have evolved such striking color patterns that they resemble brilliant flowers. Others are so strangely shaped that they appear to be inert twigs until some atypical movement reveals their presence to the close observer. Peculiar adaptations among higher plants are by no means rare. Not a few have lost their ability to manufacture their own food through photosynthesis and some of them have even become parasitic on other living plants. None can match the members of the genus *Cuscuta* which have evolved in so many ways that they resemble fungi.

There is no doubt that the members of the genus, the dodders, are truly green plants. As seedlings they are faintly colored with chlorophyll. They have stems, roots, and leaves, and develop flowers, fruits, and seeds. The genus is grouped with less peculiar green cousins, the bindweeds and morning-glories, in the large family, Convolvulaceae.

FUNGAL RESEMBLANCES

Not long after germination the seedlings begin to lose some of the characteristics of higher plants. Their leaves, never more than tiny scales, are retained, but the chlorophyll, essential for food production, disappears. Soon the twining



Fig. 15. Stems and flower buds of *Cuscuta*

plant's connection with the soil through its own root system breaks and the young yellow, orange, or reddish stems are dependent on an external source of food, as are the fungi. (Timing is of the essence because there are no food-rich cotyledons in the seed.) If none suitable is at hand, such as a susceptible green host plant, the would-be parasite dies. The stems of dodder are no more than a millimeter or so in diameter, but like even smaller fungal filaments, they can grow at rapid rates, and clamber and twine about the host plants like mold on strawberries. The stems from a single seed can form an entangling colony more than a hundred square feet in area in a single season. In so doing, the appearance of the host plant is altered, not only by the ghostly net encompassing it but by the color changes brought about by the parasitic activity of the dodder within its structure. Chlorosis and stunting are not unusual symptoms, although some species of green plants are injured less than others. Even though the large planting of English ivy pictured in Fig. 14, was densely covered and there were enormous numbers of parasite penetrations (Fig. 15), only a little chlorosis and distortion of leaves was noted. The same cannot be said of a number of crop plants such as clover, alfalfa, flax, onions, tomatoes, and potatoes.



Fig. 14. Garden planting of *Hedera Helix* enmeshed by stems of *Cuscuta* sp.

There are well over a hundred species of dodder in the world, of which about 30 are native

to the United States. Some of them have wide host ranges that might include weed plants and perennial as well as annual hosts. The same can be said for many parasitic fungi.

Like the mistletoes, dodder plants form a penetration organ called the haustorium. Although this, in higher plants, is morphologically equivalent to an adventitious root, there are stages during its development in which strands of parasite cells resembling fungal hyphae invade the cortex, phloem (food conducting tissue), xylem (water and mineral conducting tissue), and pith (Fig. 16). The first stage of attack is the formation of a "sucker" by the parasite. This is a swollen area in which the epidermal cells of the dodder are elongated perpendicularly to the surface of the host. A bulge from the sucker begins to enter the host, presumably by pressure and enzymatic action. It gives rise to the strands of cells, called hyphae, that ultimately reach the vascular tissues of the green plant. There they assume morphology and function like those of the cellular components of the tissues themselves. Early investigators of this connection knew that the dissolution of the cell wall of the dodder permitted its protoplast to be applied directly to specialized areas of the phloem cells, but did not believe that the protoplasts of host and parasite fused.

There is another remarkable similarity between dodder and fungi. The hyphae of some

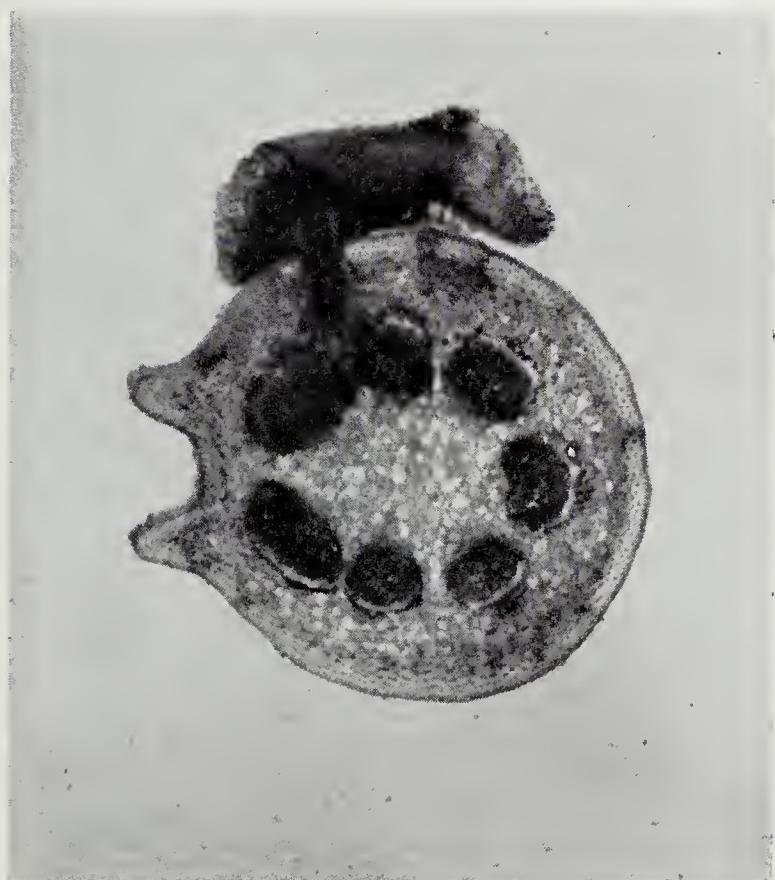


Fig. 16. Cross-section of *Hedera* petiole with haustorium of *Cuscuta*



Fig. 17. Cross-section of *Cuscuta* stem with haustorium of *Cuscuta*

fungi freely anastomose with one another, forming living bridges between parts of the branching hyphal system. It has been shown that *Cuscuta californica* Choisy and *C. subinclusa* Dur. & Hilg. will parasitize themselves and other species of dodder. Fig. 17 is a photomicrograph of a section of the stem of an additional species (probably *C. Gronovii* Willd.) and a portion of an attached spiral of the same species that has formed an haustorium within it.

The resemblance does not end here. Many fungal pathogens, such as the one causing ergot of grasses, manufacture toxic chemicals. There are scattered reports that farm animals can be seriously sickened by feeding on plants parasitized by dodders. Although the implication has been made that the parasites render the host tissue poisonous it seems more likely that the sickening compounds are obtained via the parasite stems that contaminate the food plants. At least one compound is an alkaloid.

VIRUS TRANSMISSION

Like other living things, plants are subject to virus diseases. A given virus might be transmissible to a few or to dozens of species of host plants. The symptoms that it causes vary from host to host. Indeed, certain plants may be "symptomless carriers"; that is, the virus can multiply inside the host cells, but fails to cause observable symptoms. Virus particles gain entrance to potential victims through wounds, natural or artificial grafts, by seed transmission, by injection from insect carriers, and by the activities of other parasites, as fungi or nematodes. Add dodder, the perfect go-between, to the list. But do not think of dodders merely as transmitting agents; they can be the victims, or sites of virus multiplication, or valuable research tools, or even unbelievably dangerous hazards to agriculture.

Students of plant viruses began to realize the potential import of dodders about 30 years ago. First they recognized that the dodder connected with the vascular system of the host, next that a stem of dodder could be attached to a host plant at one end and a second at the other end. Finally came full realization of the significance of the fact that the first host plant need not necessarily be of the same species as the second. Researchers found that pieces of dodder stem as short as one or two inches could be used as starting material, and investigated the ability of the parasites to transmit a variety of well-known viruses. Such broad-host-range viruses as cucumber mosaic virus, aster yellows virus, sugar beet curly top virus, bushy stunt virus, and tobacco mosaic virus are transmitted well. Tobacco ring spot and pea wilt viruses are not. It was found that dodder is best at transmitting those viruses to which it is susceptible. Further, by assaying the dodder tissues it was shown that some of the viruses increased in number in the dodder bridge but that tobacco mosaic virus does not.

There is at least one virus that finds in dodder its natural abode. Since dodder is scarcely to be considered a valuable crop the fact that it was so afflicted came to light only when the virus, called dodder latent mosaic virus of *C. californica*, *C. subinclusa*, and *C. campestris* Yuncker was transmitted to more "attention-worthy" hosts. Although the insect vector, if any, is not known, the virus can be transmitted from plant to plant of *C. campestris* through seed and from the dodder hosts to sugar beet, cantaloupe, potato, tomato, celery, buckwheat, and a variety of important ubiquitous weed hosts, as well as to certain useful virus-indicator plants. The symptoms are either masked or of short duration in most of these hosts, but can be seriously damaging in cantaloupe and buckwheat.

The dodder bridge may be affected adversely by transmitting viruses from plant to plant. Curly top is so potent a destructive agent of phloem that once the dodder has transmitted the virus it no longer can establish additional haustoria in the damaged host plant phloem.

Investigations of plant viruses are frequently hampered by the inability to obtain transmission of virus to useful indicator plants or to additional specimens of the sort presumed to be affected. Some, like tobacco mosaic virus, can be transmitted by rubbing the leaf of a healthy plant with juice from a diseased one. Others are transmitted in nature only by certain insects. Discovering what the insect vectors are is a project of no small proportions. Frequently when the insect pest responsible for the travel arrangements of a virus under study is unknown, the researcher will try to graft healthy and diseased plants. Interspecific grafts are difficult enough between healthy specimens, thus the use of fast-growing dodder bridges is an appealing alternative. By means of dodder, some viruses have been transmitted to dozens of new host plants. Quite early in such work it was pointed out by a senior scientist that extraordinary care must be taken to screen such host plants from all insects. In nature, viruses are restricted by the prevalence of host plants and by the host range of the insect vectors. If, by means of dodder, viruses are introduced to additional host species, completely different populations of transmitting insects can be made vectors if allowed to feed on the newly diseased plants.

ENVIRONMENTAL INFLUENCE ON DODDER ACTIVITY

In view of the fact that dodders may have broad host ranges and can even feed on several different species simultaneously, one might conclude that they are relatively impervious to environmental fluctuations or changes in the physiology of the host. This is not necessarily so. Not only is the ease with which viruses can be transmitted influenced by host function, but the very survival of the dodder is dependent upon the coordination of its life cycle with that of its food supply. Some dodders are perennial on perennial hosts (e.g. *C. reflexa* on *Salvia*), annual on annual hosts.

Some interesting relationships between host and pathogen were turned up by investigators of virus transmission who endeavored to standardize methods for consistent disease development in recipient plants. Poor transmission of tobacco mosaic virus was obtained when the dodder was allowed to grow freely between the donor (diseased) tomato plant and the recipient. Pruning the growing tips of the dodder helped, but

the most significant increase was obtained when a light-proof barrier was placed between the two plants. The dodder bridge went through the barrier from the illuminated donor plant to the darkened recipient. Presumably, the flow of materials in the phloem, including virus particles, was improved when the recipient was not photosynthesizing.

The matter of synchrony of life cycles is of fundamental importance to the dodder. The annual host plant cannot survive unfavorable weather conditions. Its offspring in the form of seeds do. So also is it with the dodder parasite that flowers and fruits at such times that the destruction of food supply does not represent disaster. The time-regulation of this reproduction process resides in the host plant for some species of dodder. One such is *C. campestris*, a broad-host-range species.

When growing as a parasite of cocklebur (*Xanthium pensylvanicum*) or soybean (*Glycine max* 'Biloxi'), this dodder will flower when the host flowers. But it does the same when growing as a parasite of *Matricaria parthenoides* or henbane (*Hyoscyamus niger*). All four of these hosts are laboratory species favored by plant physiologists who study floral induction in relation to light and hormones. The first two flower only when the day length is short; the second pair are representative of the sort of plants that will not bloom under short day conditions but will do so when days are long. The experiments that demonstrated these relationships are interesting enough but studies of flowering plants held under short-day conditions bridged with dodder to plants under long days have yielded evidence for the theory that flowering in some higher plants is regulated by a two-hormone system, one, formed under flower-inducing day length that promotes floral induction, and another, formed during noninductive periods, that suppresses flowering.

CONTROL OF DODDER

A genus so rich in species, so widely distributed about the globe, so versatile in its capabilities must be termed a successful one. As might be

expected, its members are extremely difficult to eradicate once established in undesirable locations. Before the advent of modern herbicides, commercial clover seed production was wiped out in Europe. Even now, the standard recommendation, in addition to purifying seed supplies, practicing crop rotation, and mowing forage crops before dodder flowering, is to rogue out the parasitized host prior to herbicide application.

I wish to express my appreciation to Mrs. J. Noel Macy of Georgetown, Washington, D.C. for permission to make photographs used in Figs. 14 and 15.

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Growth and Characteristics of Some Hybrid Spruces

FRANK S. SANTAMOUR, JR.

For many years (1946-63) the Genetics Project of the Northeastern Forest Experiment Station, U. S. Forest Service, was located at the Morris Arboretum in Philadelphia, Pennsylvania. During this period, many interspecific hybrids in various tree genera were produced, and specimens were outplanted at the Arboretum and at other locations throughout the Northeast for evaluation. The spruce hybrids described in this report were produced by Dr. Jonathan W. Wright while he was with the Northeastern Station.

Pollinations were made in 1955 and 1956, with no bagging of the female conelets. Wright¹ has reported the value and speed of this technique when spruces are rare in a given area. Seed were stored in stoppered vials in a refrigerator until the spring of 1958. At this time, following a 10-day cold soak, the seed were sown at the New Jersey State Nursery, Washington Crossing, N.J. The resulting seedlings were lifted in the spring of 1961 as 3-0 stock and at least three seedlings of nearly every seedlot produced during the above years were given to the Arboretum. All of these progenies are also under test by the U. S. Forest Service in Maine. The Arboretum seedlings were planted 3 feet apart in rows 3 feet apart on the Arboretum nursery area and the entire planting occupied only 1500 square feet on this very uniform site. Placement of the various seedlots was entirely at random although there was no replication. The planting area was



Fig. 19. *P. glauca* × *pungens*



Fig. 18. *P. glauca* × *Engelmanni*

cultivated for the first three years following out-planting. Measurements of height to the nearest 0.1 foot and data for the determination of hybridity were taken in September 1966, just prior to the removal of a large number of trees to their permanent locations in the Arboretum. The trees were nine years old from seed at the time of measurement, and survival was 83 percent.

DETERMINATION OF HYBRIDITY

The identification of spruce species is often times a difficult proposition, although the data compiled by Wright¹ are of considerable help.

¹ Wright, Jonathan W. Species crossability in spruce in relation to distribution and taxonomy. Forest Sci. 1:319-349. 1955.

TABLE 1. NINE-YEAR HEIGHT GROWTH OF HYBRID SPRUCES

Cross		Seedlots	Trees	Av. Ht.	Av. Ht.
		number	number	feet	feet
<i>Picea -</i>					
<i>Abies</i> ¹	×	O.P. ²	2	6	5.30
	×	<i>Abies</i>	2	8	5.25
	×	<i>asperata</i>	6	19	5.30
	×	<i>Koyamai</i>	2	5	5.64
	×	<i>montigena</i>	4	12	4.71
	×	<i>Wilsonii</i>	2	5	6.00
<i>montigena</i>	×	O.P.	1	2	2.40
	×	<i>Abies</i>	1	3	3.96
	×	<i>asperata</i>	1	2	2.10
<i>glauca</i>	×	O.P.	1	3	3.83
	×	<i>glauca</i>	2	5	4.74
	×	<i>Engelmanni</i>	4	9	4.34
	×	<i>jezoensis</i>	3	6	5.00
	×	<i>Koyamai</i>	1	2	3.05
	×	<i>pungens</i>	2	5	5.76
<i>Engelmanni</i>	×	<i>glauca</i>	1	3	3.40
<i>pungens</i>	×	<i>pungens</i>	1	2	3.50
<i>Omorika</i>	×	O.P.	3	9	3.76
	×	<i>Omorika</i>	2	4	3.55
	×	<i>Koyamai</i>	3	6	3.53
	×	<i>orientalis</i>	4	9	3.78
<i>orientalis</i>	×	O.P.	3	8	1.60
	×	<i>orientalis</i>	3	8	1.74
	×	<i>Abies</i>	1	2	1.40
	×	<i>montigena</i>	1	3	5.83
	×	<i>Omorika</i>	1	3	1.80
	×	<i>Wilsonii</i>	1	2	1.45

¹ Female parent listed first in crosses.² O.P. — open (wind) pollination.³ Progenies from same female parent.⁴ Judged to be non-hybrid.

The situation becomes more difficult when certain distinctive characters useful in the identification of mature specimens are not expressed in young trees; e.g. resinous buds and pubescent branches in *P. montigena*, loose bud scales in *P. glauca*. The identification of interspecific hybrids, even when the putative parents are known, is hindered by the uncertainty as to whether a key characteristic of one parent is not expressed because of juvenility or non-hybridity. In the present study, some of the parent trees were within effective pollination range of other trees of the same species. Because the female flowers were not isolated, intraspecific variation among non-hybrid progeny might tend toward characteristics suggesting hybridity in some cases.

The progenies used in this study had not been critically examined for hybridity before 1966. Because of the difficulties involved in the verification of hybridity, it is suggested that putative spruce hybrids be grown in a green-

house, as Fowler² did in the determination of *P. Shrenkiana* × *glauca*, to allow for early and continual observation.

Branch specimens of putative hybrids were compared with intraspecific progeny of the same female parent whenever possible. Otherwise, open-pollinated progeny of the same age from the same or other females were used as a guide. Significant deviation from the species standards, especially with regard to the expression of male characteristics, was taken as an indication of hybridity.

Many hybrids, especially those involving *P. glauca* as the female, were fairly easy to verify. For example, the combination *glauca* × *jezoensis* had 1-2 incomplete stomatal rows on the lower needle surface and 5-6 rows on the upper surface.

² Fowler, D. P. A new spruce hybrid — *Picea Schrenkiana* × *P. glauca*. U. S. Forest Serv. Res. Paper NC-6, pp. 44-47. 1966.

The female parent normally has 3-4 rows on all surfaces while the male parent lacks stomates on the lower surface. The hybrid *glaucia* × *Engelmanni* (Fig. 18) exhibited the branch pubescence of the male parent, especially on or near the sterigmata. Many characters of *P. pungens*, such as sharp needles, acute buds, loose bud scales, and lack of skunk odor were expressed in the hybrids between *glaucia* and *pungens*. (Fig. 19). This combination is the only one in the present study that was not reported previously by Wright¹. Some rather subjective traits, including bud color, were used to identify *glaucia* × *Koyomai*.

Hybrids involving *P. Abies* were more difficult to evaluate. Certain major traits, such as resinous buds of *P. asperata* and *P. montigena* were not expressed in the putative hybrids. Without going into any details on hybrid characteristics, it was decided for the present, to consider all interspecific crosses on *P. Abies* and *P. montigena* as hybrids. Further observations may show that some individuals of certain progenies do not merit hybrid status.

Except for the single seedlot of *P. orientalis* × *montigena*, which was an obvious labeling error and tended toward *P. Abies*, all seedlots with *P. Omorika* or *P. orientalis* as female parents were considered non-hybrid. The trees of these species that were used as parents were growing in small groups and probably received considerable intraspecific pollination. Wright¹ has mentioned that the cross *Omorika* × *orientalis* was not always successful.

HEIGHT GROWTH

Data on height growth are presented in Table I. Because of the small number of trees involved and the statistical limitations imposed by the planting design, it is probably best to let the data "speak for themselves." It can be seen that the fastest growing of the *P. Abies* hybrids is *Abies* × *Wilsonii*, while the slowest growing is *Abies* × *montigena*. The true significance of the differences in height between reciprocal combinations of *Abies* and *montigena* and between *glaucia* and *Engelmanni* cannot be determined because different parents were used. The only hybrid combination that appears to show any degree of hybrid vigor is *glaucia* × *pungens*. (Fig. 19) The best individual tree of this hybrid measured 7.9 feet while the tallest *glaucia* was 6.4 feet.

Judging from the results of this study and observations made on earlier hybrid spruce plantings, there is little to be gained, in growth rate, by interspecific hybridization. Selection and utilization of superior trees and stands of *P. Abies* and *P. glauca* should supply fully adequate forest planting stock for most areas of the Northeast. It is possible that certain combinations, especially those involving *P. montigena*, may have desirable horticultural characteristics. Interspecific hybridization will only become a major factor in spruce improvement when, and if, certain combinations are shown to be resistant to some of the more destructive insect and disease pests of the region.

Associates' Corner

WHY VISIT THE ARBORETUM

In the first place here, in nearly 180 acres, are over 3,000 different kinds of trees and shrubs. They are not scattered hither and thither but are carefully and artistically grouped according to their families, so that a thoughtful person can make comparisons.

The most important collections are the azaleas near the Swan Pond, which may be expected to be at their height of bloom around the middle of May. The Rose Garden is on the South Slope below the Mansion and the best time to see it is in early June. The Heath Garden and the Medicinal and Bog Gardens are not too far away. One of the most interesting groups which

has recently been established is called the Bark Collection. This consists of an assemblage of trees with interesting and unusual bark characteristics.

In addition to the above, the Arboretum is rich in other plant material such as hollies, oaks, magnolias, viburnums, barberries, rhododendrons, or you name it. For instance while touring the Rose Garden in Spring you will see a colorful group of alpine plants on the wall surrounding it. Then there is the dramatic Franklinia tree, discovered by John Bartram in 1765 and unknown in the wild for many years. There are several in the Arboretum, the largest along the stream near the Log Cabin.

One of the gems of the Arboretum is the tropical fern house. Unfortunately, due to regrettable vandalism, this has to be kept locked, but the key can be obtained at the Office, 9414 Meadowbrook Avenue, and while there it would be advisable to obtain the official brochure which includes a map as well as the history and nature of the Arboretum. This will save many steps and help in deciding what one wants to see.

Few persons realize that within the Arboretum there are about ten acres of native woodlands situated along the steep banks of the Wissahickon Creek. It is a small cross-section of a typical eastern mixed hardwood forest. The area is traversed by winding trails which furnish a welcome shade in summer and relief to concrete-saturated eyes at all seasons. One of the best times to visit this lovely spot is in the Spring when the masses of spring bulbs and woodland flowers delight one after the long winter. A return visit is recommended in the Fall to see the glorious autumn foliage. This locality is especially popular with bird-watchers at all seasons.

Ivy-fanciers have come from considerable distances to inspect the Arboretum's collection of hardy clones, said by Dr. G. H. M. Lawrence, the outstanding authority on this group of plants, to be the finest of its kind in this country.

Many plants and trees need cross fertilization accomplished by the busy bee. To help them in this noble work the Langstroth Bee Garden was dedicated in 1952, in honor of the Philadelphia clergyman who revolutionized the art of bee-keeping.

These are the major reasons for visiting the Arboretum, but the joy of being able to stroll along, away from the roar of motors and carbon monoxide, and fill one's lungs with pure air is a lure in itself.

We are frequently asked "How many visitors do you have in a year?" This is difficult to answer as the Arboretum is not equipped to keep an official count, but it is safe to say between 15 and 20 thousand a year. One factor which has materially increased attendance this last year has been Dr. Fogg's short talks over Radio station WFLN every Friday at 1 P.M., which stress what is taking place in the Arboretum that particular week.

And certainly those of you Associates who actually read your Bulletin can not fail to have your appetites whetted and your bump of curiosity excited by constant references to what is happening in this, your growing Arboretum.

MARION W. RIVINUS

Arboretum Activities

(Continued from Page 2)

During the Spring term the following members of the staff have been conducting courses in the Department of Botany on the campus: Dr. Fogg (Plant Geography); Dr. Li (Taxonomy of the Angiosperms); Dr. Allison (Mycology).

On January 18 the Director gave an illustrated lecture to the Evergreens Garden Club on "The New Jersey Pine Barrens" and on January 22 he spoke on the "Bogs, Barrens and Beaches of South Jersey" to the Princeton Chapter of the American Rhododendron Society. At an evening meeting for the members of the Pennsylvania Horticultural Society he presented a lecture-demonstration on "Pines — their History and Identification."

On February 17 Dr. Fogg spoke to the Garden Club of Jupiter Island, Hobe Sound, Florida, on "Botany and Medicine", a lecture which he repeated for the members of the Germantown Arts and Science Association on February 27.

THE WINTER'S WORK

Most of the outdoor activities at the Arboretum this winter have been concerned with "house-cleaning." Labels have been repaired or

replaced, trees and shrubs have been fertilized or mulched, the woodshed on the farm has been re-habilitated, many plants have been pruned and several large trees which are either dead or dying have been removed. This last operation is a sorry one. Few things are more tragic than to see a noble tree succumb to the ravages of time, disease, injury or drought. We take solace, however, in the fact that in all cases younger and more robust replacements have been propagated or are already established to take the place of their predecessors.

ANNUAL PLANT DISTRIBUTION

The dates for the Annual Distribution of rare or unusual plants to our Associates have been set for Friday (9 A.M. to 4 P.M.) May 26 and Saturday (10 A.M. to noon) May 27. As has been the case in recent years, plants will be distributed from the area surrounding the Morris Mansion and parking will be provided in the immediate vicinity. Closer to the date each Associate in the Philadelphia metropolitan area will receive in the mail a notice of this event.

J. M. F., Jr.

Flower Show Exhibit

For the annual Spring Philadelphia Flower Show, held from March 12 to 19, the Morris Arboretum prepared an exhibit which was entitled "Pines of the World."

More than 40 species, varieties and cultivars of the genus *Pinus* were represented by carefully selected living plants, attractively grouped so as to bring out differences in their habit or manner of growth, as well as the length, color and texture of their foliage. (Fig. 20).

The plants in the display varied from low-growing specimens of bristlecone pine (*P. aristata*) and mountain pine (*P. Mugo*) in the front to 7-or-8-foot tall trees of Virginia pine (*P. virginiana*) and Loblolly pine (*P. Taeda*) at the rear.

Each specimen bore a key number which, on a long placard at the front of the exhibit, was translated into its botanical and common names, together with information concerning the native home of the species, its economic value, horticultural importance, etc.

From a globe of the world, mounted on a pedestal at the center of the display, there extended colored ribbons indicating the main geographic centers of distribution of the species included in the collection.

On a large board against the back wall were mounted cones and branches of many of the pines on display. The former varied in size from the tiny cone of the Jack pine (*P. Banksiana*) to the massive cone of Coulter's pine (*P. Coulteri*), which weighs several pounds.



Fig. 20. General View of the Exhibit.



Fig. 21. Detail showing Dragon-eye Pine

One of the most interesting plants on view was the Dragon-eye form of Japanese red pine (*P. densiflora* 'Oculis-draconis') (Fig. 21) and one of rarest was Gerard's pine (*P. Gerardiana*) a native of the Himalayas.

For anyone who may have wondered whether a "Garden of Pines" could be a thing of beauty and horticultural interest this exhibit was a real revelation.

To our Superintendent, Mr. John Dourley, belongs great credit for having grown or obtained the material for this unusual display, as well as for the manner in which the plants were arranged and information concerning them conveyed to visitors.

Grateful acknowledgment is also due Dr. Frank S. Santamour, Jr., who checked many of the identifications.

Although not in competition "Pines of the World" was given the Gold Medal Award of the Pennsylvania Horticultural Society.

Following is the list of species and varieties included in the exhibit:

- P. albicaulis
- P. aristata
- P. Armandii
- P. attenuata
- P. Banksiana
- P. Brutia
- P. Brutia eldarica
- P. Brutia pithyusa

P. Bungeana	P. Mugo
P. Cembra	P. muricata
P. cembroides	P. nigra
P. contorta	P. parviflora
P. contorta latifolia	P. Peuce
P. Coulteri	P. Pinaster
P. densiflora	P. Pinea
P. densiflora ‘Oculis-draconis’	P. ponderosa
P. densiflora umbraculifera	P. pungens
P. flexilis	P. rigida
P. Gerardiana	P. Sabiniana
P. Griffithii	P. Sosnowskyi
P. halapensis	P. Strobus
P. Heldreichii	P. Strobus nana
P. Jeffreyi	P. sylvestris
P. koraiensis	P. sylvestris Watereri
P. Lambertiana	P. tabulaeformis
P. monticola	P. Taeda
	P. virginiana

J. M. F. JR.

New Associates

The Arboretum is happy to welcome the following new
Associates who have been enrolled since December, 1966:

Mr. Cornelius VanReypen Bogert, Jr.

Mr. Daniel P. Nelson

Mrs. E. T. Comly, II

Mrs. Jay Raab

Mr. & Mrs. Herbert J. Garber

Mrs. Russell Trenholme

Dr. David A. Hungerford

Mrs. Calvin Wigginton

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Chamaecyparis Lawsoniana at Bodnant Garden

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THE ASSOCIATES, through whose interest and generosity *The Bulletin* and certain other undertakings of the Arboretum are made possible, is an informal group of individuals interested in encouraging and furthering the educational and research endeavors of the Morris Arboretum.

CLASSES OF MEMBERSHIP

Contributing	\$ 5.00 a year	Supporting	\$ 25.00 a year
Sustaining	\$10.00 a year	Sponsoring	\$100.00 a year
	Donor		\$500.00

Arboretum Activities

The new Director finds it difficult to observe brevity in recording his enthusiasm for the beautifully varied landscape and flora of the Morris Arboretum. There is pleasurable discovery on every hand. It is obviously impossible to bring to your attention each of the plants notable for unusual attraction this Spring. Certainly worthy of mention are *Enkianthus perulatus* with its profusion of white blossoms, the unusual pink-flowered form of *Halesia monticola*, the selected cultivars of *Erica cinerea* and *E. tetralix*, the vivid color forms of *Rhododendron calendulaceum*, the sweetly fragrant *Magnolia × Thompsoniana*, and lastly the rather unbelievable *Fagus*

sylvatica roseo-marginata of relatively restricted stature with leaves of conspicuous rose coloration.

The prolonged cool moist Spring has permitted considerable progress to be made in rearranging the plantings. Our Superintendent, Mr. John Dourley, has devised a very effective arrangement of Dwarf Conifers near the Medicinal Plant Garden. Close by, a new area has been cleared of such disposable species as *Rhus Toxicodendron* and elegantly replaced by various species of native Azaleas as well as several species of *Hypericum* transplanted from the thriving Heather Garden where the additional space thus

(Continued on Page 40)

The Morris Arboretum 1967 Tour

JOHN M. FOGG, JR.

From May 11 to June 1 my wife and I conducted a group of 35 persons on a Garden Tour of Ireland, Wales, England and Scotland. Leaving New York by regularly scheduled jet flight, we arrived in Shannon, Ireland, on the morning of Thursday, May 12. From Shannon we transferred to the hotel in nearby Limerick which was to be our home for the night.

In front of the hotel was a rock garden containing several genera seldom seen in the eastern United States. Among them were various kinds of *Ceanothus* with misty blue flowers (these are native to western North America) and at least two species of *Olearia*, a genus of shrubby Composites indigenous to Australia and New Zealand.

Following lunch we set out by motorcoach on a sightseeing tour which took us to Bunratty Castle, Six-mile Bridge, Ennis and the 12th century Quinn Abbey. Of this initial contact with rural Ireland one's lasting impressions must be stone walls, flocks of sheep, ruined castles, but especially gorse. (Fig. 22) This ubiquitous plant (*Ulex europaeus*), known also as furze or whin, flaunts its golden flowers from every field and roadside and is said to be in bloom practically throughout the year. Occasionally it is replaced by patches of Scottish Broom (*Cytisus scoparius*). Another salient feature of this country, and indeed of most of Britain as well, is the presence of hawthorn hedges along each lane and highway. These were just beginning to flower while we were there.



Fig. 22 Stone walls and gorse in southwestern Ireland



Fig. 23 Botanic Gardens of University College, Oak

Saturday, May 13, was initiated under a dull sky with threats of rain, which soon materialized. Indeed, this day established the weather pattern for most of our tour, since during the entire three weeks we had only three fully clear, sunny days. Our only consolation, if such it can be called, was that each letter from home indicated that similar conditions were prevailing there.

From Limerick we drove along the River Shannon to Adare to visit Demesne, the magnificent estate of the Earl of Dunraven. The winding and seemingly endless driveway which led up to the Georgian manor was lined with century-old oaks, lindens, elms, and maples. Irish yew (*Taxus baccata*) and laurel-cherry (*Prunus Laurocerasus*), which we are accustomed to seeing as small shrubs at home, were here 30 to 40 feet tall.

One of the greatest surprises, however, was to find the Monterey cypress (*Cupressus macrocarpa*) represented by towering specimens 70 or 80 feet in height. This species, which enjoys a restricted distribution in California, is not fully hardy in the Philadelphia area. Another California tree which dominated the open woodlands here was the Monterey pine (*Pinus radiata*). Subsequently we saw both of these western conifers grown to superb proportions in other gardens in Ireland and southern England.

On the side of the manor toward the river there stands an immense specimen of Cedar of Lebanon (*Cedrus libani*), said to be some 600 years old.



Fig. 24 Powerscourt, general view

It was here that we first encountered two shrubs which were unfamiliar to most of us, but which we were to see in almost every garden which we later visited. One was the yellow-flowered *Corokia Cotoneaster*, a member of the Cornaceae which is native to New Zealand; the other the attractive white-flowered *Choisya ternata*, which comes from Mexico and belongs to the Rutaceae.

There was much more of interest to be seen here and had it been a fair day there is no telling how long we might have lingered. Dampened in person, though not in spirit, we retreated to our coach and set out on the 60-mile drive through Newcastle and Abbeyfeal to Killarney, where our hotel was situated at the very edge of one of Ireland's most beautiful lakes. Although we spent a day and two nights here, the clouds hung so low that we never caught a full view of the opposite side of the lake.

The gardens surrounding our hotel were replete with plants which the inhabitant of our eastern states seldom or never sees in cultivation. Among these were *Pernettya mucronata*, from the



Fig. 25 *Gunnera manicata*

tip end of South America, and various species of *Hebe*, mostly native to New Zealand.

Sunday, May 14, was devoted to the scenic "Ring of Kerry" tour which encircles the Iveragh Peninsula and provides some of the finest panoramas in southwestern Ireland. Had the sun shone, the experience would have been truly spectacular, but as it was we were treated to a succession of impressive misty views of the Atlantic Ocean from lofty cliffs and hairpin turns. At one place where there was a "lay-by" for our coach, we piled out to take pictures and inspect the plants on the rock-face which rose precipitately from the side of the road. Here were several species of *Veronica* and *Primula*, but the most exciting was *Saxifraga hirsuta*, its fleshy rosettes of bright green leaves forming a attractive setting for its clusters of rose-colored flowers.

As we neared Parkasnilla, where a luncheon stop was scheduled, our guide assured us that we would be entering the topics, with palms on all



Fig. 26 Scree and rock gardens, National Botanic Garden, Dublin

sides. The vegetation was certainly of a warm temperate, though not tropical, nature, again with *Ceanothus* and *Olearia* much in evidence, but the "palms" proved to be *Cordyline australis*, another introduction from New Zealand. *Rhododendron ponticum* is widely established in this area and is regarded as a troublesome weed!

Our continuation of the "Ring" that afternoon took us through many miles of bogland valued chiefly because its thick deposits of peat are mined and burned in plants which furnish electric power to large areas in southern Ireland. Before returning to our hotel in Killarney, we experienced a jolting ride in a jaunting-car through the heavily wooded Muckross Estate.

The following morning, May 15, we departed from Killarney — destination Cork. Our route



Fig. 27 Aquatic house, National Botanic Garden, Dublin

took us over the Derrynasaggart Mountains and through Macroom. After a detour to Blarney Castle (where, be it recorded, not a single member of the party elected to kiss the stone) we arrived in time for luncheon in Cork.

Our first visit of the afternoon was to the Cork University Botanic Garden where we were graciously received by Dr. Oliver W. Roberts, the Director, and members of his staff who, after our tour of the garden, offered us tea. Although only two acres in extent this garden includes a comprehensive series of herbaceous beds containing the families of plants arranged in systematic sequence and a goodly collection of trees and shrubs. (Fig. 23). Here in full bloom was *Sophora tetaptera*, the national flower of New Zealand, and several species of *Sorbus*.

We were greatly intrigued by an evergreen shrub with rich crimson bell-shaped flowers borne on pendulous stalks. The plant was labeled *Tricuspidaria dependens* and according to Bean's "Trees and Shrubs hardy in the British Isles" (Edition VII, 1951) is a member of the Tiliaceae from Chile and Peru. More recent



Fig. 28 *Cedrus atlantica glauca* at Bodnant Garden

writers have transferred it to the genus *Crinodendron* and assigned it to the Elaeocarpaceae. If this treatment is accepted, then its correct name would seem to be *C. Patagua* (*C. lanceolata*), since *C. dependens* has white flowers. Here also were *Fabiana imbricata* (which although it strongly resembles a heather, is a member of the Solanaceae) and *Eugenia apiculata* (of the Myrtaceae), both of them natives of Chile. This small garden is indeed well worthy of a visit.

FOTA ISLAND

Fota Island, just south of Cork, the private arboretum of Major and the Honorable Mrs. Bertram Bell, boasts one of the finest collections of rare trees and shrubs to be found anywhere and it was our very good fortune to be welcomed there and shown around by the owners. Had we been able to take pictures or make notes at Fota, instead of dodging raindrops, it might be possible to convey some adequate impression of the



Fig. 29 Garden at Whately Hotel, Banbury

vast richness of this collection. As it is, all that can be done is to offer a few random observations.

The strong element of plants from the Southern Hemisphere which we had already noted was here even more in evidence. Among the conifers were the Huon Pine (*Dacrydium Franklinii*) from Tasmania and *Podocarpus chilina*, a native of South America. The Myrtle Family or Myrtaceae was represented by *Feijowa Sellowiana* from Brazil and Uruguay, *Eugenia apiculata* from Chile, and several species of *Eucalyptus* from Australia. We were delighted to see the brilliant scarlet flowers of *Embothrium longifolium*, a member of the Proteaceae which is also indigenous to Chile.

Western North America was not neglected, for here was a superb specimen of that rarest of all spruces, *Picea Breweriana* found only in



Fig. 30 *Magnolia grandiflora* espaliered at Warwick Castle

southwestern Oregon and adjacent California. Aptly known as the weeping spruce, its slender branches hang down almost perpendicularly. Here, too, were massive trees of California redwood (*Sequoia sempervirens*), barely hardy in the Philadelphia area, with trunks three or four feet in diameter. The big tree (*Sequoiadendron giganteum*) was here, as was also the incense cedar (*Libocedrus decurrens*), both far larger than is ever the case in our eastern states. Paradoxically, the only conifer which does not seem to do as well in southern Ireland as it does at home is the dawn redwood (*Metasequoia glyptostroboides*).

One of the most striking plants at Fota was the Asiatic *Pieris Forrestii*, in which the young foliage is of a pale salmon color. The rare *Magnolia Wilsonii*, in full flower, was also a thing of beauty.

It is to be hoped that this abbreviated list may convey some slight impression of the tremendous variety of plant materials in this truly amazing private collection.

From Cork, at 6 P.M., we took the fast train to Dublin, arriving at the renowned Jury's Hotel in the capital city before dark.

POWERSCOURT

On the morning of May 16 we drove south from Dublin to Powerscourt, the palatial estate of Mr. and Mrs. Ralph Slazenger at Enniskerry. (Fig. 24). The entrance to the grounds is through an artistically designed bronze gate and similar gates separate the various formal gardens as one moves from one section to the next and more impressive one. Standard trees of *Prunus lusitanica* line the walk in front of the mansion and from them the land slopes in a series of descending terraces, each level imparting vistas of water and massed rhododendrons. Imposing pieces of statuary contribute to the sumptuousness of the overall effect of an Italian garden. One fascinating feature was a grotto constructed entirely of petrified peat and planted with ferns, selaginellas and mosses.

Although much of Powerscourt is formally landscaped, vast areas have been allowed to remain as woodland with either native or introduced trees. The largest specimens of Scots pine (*Pinus sylvestris*) we saw on our entire tour were growing here. This species is believed not to be native to Ireland, but is everywhere planted and grows to a great size.

Mt. USHER

From Powerscourt we continued southward to Mt. Usher, the private garden of Mr. and Mrs. Robert Walpole at Ashford in Co. Wicklow. It had been our privilege to receive the Walpoles when they visited the Arboretum several years ago and ever since they had been urging us to pay them a return visit. I am sure they did not expect us to have 35 other persons with us, but they were more than equal to the occasion and provided a delicious luncheon for our entire party as soon as we arrived.



Fig. 31 Garden at Anne Hathaway's cottage, Stratford-upon-Avon



Fig. 32 *Cupressus macrocarpa* at Welcombe Hotel,
Stratford-upon-Avon

Following lunch we sauntered forth, armed with rubbers, slickers, rain-hats and umbrellas, to inspect what has been described as the finest private garden in Ireland. Here were many of the same species we had seen at Fota Island, plus a considerable number of new and interesting plants. Once more, the southern hemisphere was dominantly represented. From South America were such conifers as *Fitzroya patagonica* (from Southern Chile and Patagonia) and *Podocarpus saligna* (from Chile). *Grevillea Aveliana* (of the Proteaceae), another Chilean species (which produces an edible nut), was also here and on the banks of the turbulent Vartry River that traverses the grounds were the huge leaves and immense inflorescences of the Brazilian *Gunnera manicata* (Fig. 25), a plant which never fails to excite wonder and admiration among persons acquainted only with our eastern American temperate vegetation.

The floras of Australia and New Zealand were even more strongly represented at Mt. Usher than those of South America. Mr. Walpole has a distinguished collection of *Nothofagus*, that group known commonly as southern beeches, and of *Eucryphia*, a genus which occurs only in South America and the Australian region. One New

Zealand species, known as leatherwood, is an important source of honey. Many species of *Acacia* are hardy here and we were delighted to see *Aristotelia racemosa* (a New Zealand member of the Tiliaceae) and *Auopterus glandulosa* (of the Saxifragaceae) an evergreen shrub which comes from Tasmania.

As one who is keenly interested in the Magnoliaceae, I was pleased to see several varieties of the Oriental genus *Schizandra*, one of two genera of vines in a family composed mostly of trees. Another Asiatic genus of climbing plants was *Actinidia*, particularly *A. Kolomikta*, with its variegated white to pinkish leaves. Among other Oriental species were *Cupressus cashmeriana* and *Illicium anisatum*.

Pacific North American was again represented by some of its noblest conifers, such as *Picea Breweriana*. The California redwood in front of the house was probably the largest we saw anywhere. That loveliest of gooseberries, *Ribes speciosum* from California was in full flower as was *Vaccinium ovatum*, and that despair of eastern American gardeners, *Garrya elliptica*, was here a robust shrub adorned with a multitude of pendulous racemes. One of the greatest treasures in the garden is a gigantic specimen of the Mexican *Pinus Montezumae*, which unfortunately the state of the weather made it impossible for us to photograph.

Words are simply inadequate to describe this amazing collection or to express our appreciation of the hospitality of our host and his charming wife and sister.

GLASNEVIN

The morning of Wednesday, May 17, was given over to visiting the National Botanic Garden in Glasnevin, Dublin. The Director, Dr. T. J. Walsh, was otherwise engaged on that



Fig. 33 Oxford Botanic Garden



Fig. 34 View of the gardens on the top of Derry and Tom's store, London

occasion, but kindly made available to us the services of two members of his staff, Mr. Thomas Crawford and Mr. Paul Meeth. As these gentlemen conducted us around the grounds we were impressed by the great diversity and fine quality of the plant material, as well as by the high standard of maintenance throughout its nearly 50 acres. The garden includes a fine rock and scree collection and a goodly assortment of dwarf conifers. (Fig. 26). Outstanding among the trees were *Zelkova crenata*, *Pinus Pallisiana* and a magnificent weeping Atlas cedar (*Cedrus atlantica pendula*).

The greenhouses, also, were models of excellence, especially those devoted to aquatics (Fig. 27) and to cacti and succulents. The nurseries where we spent the final minutes of our visit, were perfection itself and the crowning touch was a tall hedge of *Cotoneaster lactea*. The morning was further notable in that we caught a few fleeting glimpses of the sun.

In the afternoon some members of the party went shopping, others embarked on a tour of Glendalough, the site of the 6th century monastery established by St. Kevin.



Fig. 35 Formal Garden at Hampton Court

BODNANT

We departed from Dublin early on Thursday, May 18 and flew to Liverpool whence, after checking in at our hotel, we left for Tal-y-Cafn to visit Bodnant Gardens in North Wales, stopping for lunch at Colwyn Bay overlooking the Irish Sea.

The garden at Bodnant is the residence of Lord Aberconway, whose father presented it to the National Trust in 1949. It is under the supervision of Mr. Charles Puddle, who kindly made the arrangements for our visit and who also provided the services of his very efficient aide, Mr. James Randall Pratt. The garden consists of two sections, the upper one near the house comprising the terrace gardens with ponds, statuary, clipped yew hedges and beds devoted to roses, azaleas, camellias, hydrangeas and magnolias. Among the last-named the Chinese evergreen *M. Delavayi* was much in evidence. Here



Fig. 36 Rock Garden at Kew

again were *Embothrium*, with its brilliant scarlet flowers, and several species of *Eucryphia*. Here, also, is the famous Laburnum Arbor, which unfortunately, was not fully in bloom when we were there.

Magnificent conifers provided a fine background for the formal gardens, among them *Pinus radiata*, *Chamaecyparis Lawsoniana* (See cover) and all three species of *Cedrus*, especially noteworthy among them an immense tree of *C. atlantica glauca*. (Fig. 28).

If one were required to select a single group of plants as most characteristic of Bodnant it would certainly have to be the rhododendrons. They are here in every conceivable shape, form and gradation of color. The garden is famous for the work in hybridizing these plants which has been carried on here for many years as well as for the large number of species which have



Fig. 37 *Pinus Pinea* at Kew

been sent to it by collectors in China and the Himalayas. A low species which attracted the attention of all of us was *R. Williamsianum*, a native of China, with bronze foliage and soft rose-colored flowers.

From the formal gardens the grounds slope steeply down through a rock garden into The Dell, where giant rhododendrons abound, interspersed with massive conifers. A specimen of the western American giant fir (*Abies grandis*) growing here is said to be the largest in Britain.

Bodnant is often called Britain's greatest garden. When one realizes that there are more than a thousand private gardens in Wales, England and Scotland which are open to the public he learns to beware of superlatives. Bodnant is admittedly in the very top rank and our visit to it was especially memorable, since this was the second of our three warm, clear, sunny days.

CHESTER, COVENTRY AND BANBURY

Departing by motorcoach from Liverpool on Friday, May 19, we drove southward to Chester with its mediaeval walls (which follow the old



Fig. 38 Chelsea Physic Garden with statue of Sir Hans Sloane

Roman fortifications) and its black and white timbered houses and shops in "Rows".

After lunch in Chester we continued on through Stoke-on-Trent to Coventry to visit the Cathedral of St. Michael which was reduced to a mere shell by the air-raids of 1940. Adjacent to it, and constructed of the same kind of light brown sandstone, an imposing new structure has been erected which is regarded as a triumph of modern ecclesiastical architecture.

Late that afternoon we checked in at Whately Hall, a picturesque and very comfortable hostelry in Banbury. Surrounding the hotel is a very attractive garden (Fig. 29) and in an alley not far away several members of the party discovered an amazing plant of *Wisteria sinensis* recorded to be approximately two and a half centuries old.

The following morning we paid a brief visit to nearby historic Warwick Castle. As our guide



Fig. 39 Rock garden at Cambridge University Botanic Garden

told us when we were looking out one of the upper rooms toward the Cotswolds, "They say that when you can see the Cotswolds from here it means rain; when you can't, it is." We couldn't, it was.

There is a fine garden surrounding Warwick Castle, replete with peacocks and espaliered *Magnolia grandiflora* (Fig. 30).

THE SHAKESPEARE COUNTRY

From Warwick we drove on to Stratford-upon-Avon to visit Anne Hathaway's cottage in its beautiful garden setting (Fig. 31), Shakespeare's grave in Holy Trinity Church and his house in Henley Street. Lunch that day was at the Welcombe Hotel, a mile or so north of the town, where I had spent several days at a scientific conference in 1957. At that time the grounds were dominated by a beautiful lake on the shores of which were elegant specimens of California

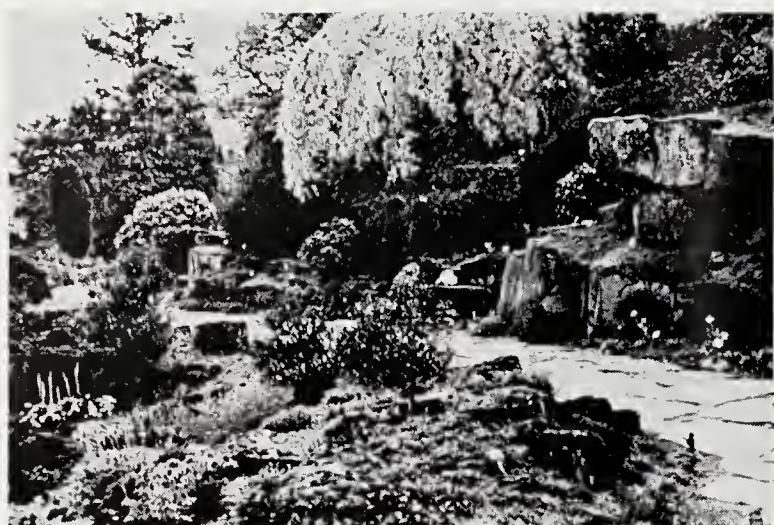


Fig. 40 Rock garden at Wisley

redwood, big tree and Monterey cypress. Today the lake has been drained and its site is occupied by a golf course. The trees still stand, however, and the cypress is shown here (Fig. 32), photographed before the clouds released their daily quota of moisture. That evening we attended a performance of *Coriolanus*, impeccably presented by the Royal Shakespeare Company in the Memorial Playhouse.

OXFORD

Sunday, May 21, witnessed our departure from Banbury by way of Woodstock where we paused briefly for a glimpse of Blenheim, the ancestral home of Sir Winston Churchill. We also paid a visit to the tomb of this great man in the simple churchyard of the Bladon Parish Church and arrived in Oxford in time to inspect several of the colleges before lunch.

Thanks to Mr. J. K. Burras, Superintendent, arrangements had been made for us to visit the Botanic Garden at Oxford that afternoon. This institution, which was founded and endowed as a Physic Garden by the Earl of Danby in 1621, is the oldest botanic garden in Britain. (Fig. 33) During the nearly 350 years of its existence it has been the scene of activities of such famous botanists as Jacob Bobart, William Sherrard, Charles Danberry and John Lawes.

Today the inner garden, which is only three acres in extent, is largely surrounded by a high wall which provides a admirable site for the display of vines and scandent shrubs. Here for the first time we saw *Eccremocarpus scaber*, a semi-woody climber with bright orange-red tubular flowers. This plant which belongs to the *Bigoniaceae* is a native of Chile. Here, too, was our old friend *Actinidia Kolomikta* as well as espaliered specimens of *Choisya ternata* and *Xanthoceras sorbifolia*. There is a small but good rock garden here and the family beds are excellent.

Viburnum Davidii from China, which grows so well on our west coast but with us is barely hardy, was here flourishing and in full flower. Four handsome species of the difficult but highly ornamental genus *Sorbus* were noted and an enormous plant of *Taxus baccata* was labeled as having been planted in 1700. Other trees of considerable age were a flowering ash (*Fraxinus Ornus*): 1790; *Pinus nigra*: 1800; and *Sophora japonica*: 1870. These are just a few of the many fine plants we saw in Britain's oldest garden. Proceeding southward from Oxford we reached our London hotel on Grosvenor Square in time for dinner.

Monday, May 22, was designated in our itinerary as a day of leisure and sightseeing. Some of us elected to have lunch on the top of Derry and Tom's department store surrounded by a unique series of gardens 100 feet above the street level.

(Fig. 34) These gardens, which were established in 1938, cover about $1\frac{1}{4}$ acres, and include a Spanish Garden, a Woodland Garden, a Tudor Garden, a Moorish Garden and a Court of Fountains. Although the average depth of the soil is said to be only about three feet, there are trees 15 to 20 feet tall, ponds with fish and water fowl, cascades and fountains. This garden is a "must" for anyone who wishes to see what human ingenuity and imagination can accomplish.

HAMPTON COURT AND WINDSOR CASTLE

These are two of the great show places of England and the morning of Tuesday, May 23 was devoted to them. Hampton Court, which is so intimately associated with Henry VIII, was first on the list and, as always, was a delight to the eye because of its beautifully manicured formal gardens (Fig. 35), its meticulously clipped hedges of oak, linden, maple and hornbeam, and its famous age-old grape-vine. Here, too, is a magnificent Laburnum Arbor, but like that at Bodnant, it was not quite ready for our battery of photographers.

Windsor Castle, rich in tradition, has little to offer to horticulturists. Nevertheless, it had to be included in our itinerary and the view of Windsor Great Park from its ramparts was well worthy of the effort. We were fortunate to be able to visit the state apartments and to witness the changing of the guard.

THE SAVILL GARDENS

Following lunch in Windsor, we repaired to the world-famous Savill Garden in Windsor Great Park. Sir Eric Savill had done his best to arrange a date when he would be able to receive us in person, but because of complications with the Chelsea Flower Show, this proved to be out of the question. He saw to it, however, that we

were cordially received at his renowned garden, in every respect save that of the weather. Our entrance through a bower of the Himalayan *Clematis montana* was most auspicious and our luck held during inspection of a small but very select collection of alpine species. Then, as we moved into the more heavily planted sections of the garden, the skies deposited their pent-up moisture upon us and we spent the rest of the afternoon dodging from tree to tree. In the midst of this deluge we caught fleeting glimpses of wonderful beds of primroses and breath-taking masses of blue poppies or *Meconopsis*. It is indeed tragic not to be able to give a fuller report of one of the most distinguished of Britain's gardens. Perhaps some future Garden Tour of the British Isles will experience more favorable weather than was accorded us.

THE ROYAL BOTANIC GARDENS AT KEW

The ideal way to see Kew, usually regarded as the greatest botanical garden in the world, is to have several days and good weather, neither of which was at our disposal. Sir George Taylor, the distinguished Director, who had promised to receive us, found himself that day (May 24) encumbered with foreign royalty, but fortunately turned our party over to one of his most competent aides, Miss Rosemary Angel.

For two hours Miss Angel guided us skillfully through intermittent showers, stopping always when it rained hardest under the sheltering branches of a noble English oak. Fortunately, just as we had traversed the family beds and were entering the rock garden, precipitation ceased momentarily and the skies brightened, permitting the taking of a few pictures (Fig. 36). This rock garden when I first knew it, was composed largely of limestone boulders. These have not stood the test of time and are gradually being replaced by slabs of sandstone. The project is still unfinished but the wonder is that already

most of the alpine species look as though they had been established for many years in their new surroundings.

Space does not permit even the briefest mention of the many sections of the grounds which Miss Angel showed us in such a very short time. One must simply visit Kew again and again in order to comprehend its many faces. For several members of our party Kew was an old story and yet it is a story that never grows old. Even our walk through the world-famous Rhododendron Dell in a downpour did not dampen our spirits, but, rather, gave us a fuller insight into the conditions in which so many of these noble plants flourish in the cloud forests of Sikkim, Nepal and on the slopes of the Himalayas.

Following lunch at the ambivalent restaurant, several members of the party retreated to the protection of Kew's many greenhouses — some to the palms, some to the orchids, some to the ferns and a select few to the cacti and succulents. I venture to say that there is no member of our party who does not look forward to the day when he or she can again go down to Kew in lilac time or any other time.

THE CHELSEA FLOWER SHOW

For many years this annual spring event has been regarded as the greatest flower show in the world and, so far as we are aware, no one has ever ventured to challenge this claim. It differs from the flower shows held in many of our eastern American cities by being almost entirely commercial, rather than supported by a large number of amateur or volunteer organizations. This circumstance is primarily responsible for its tremendous reputation, for scores of Britain's finest nurseries, growers and breeders exhibit their wares in a tastefully arranged series of quadrangular plots under a marquis which seems to cover a vast number of acres (actually it is only about $3\frac{1}{2}$). Anyone who regularly reads the Gardeners Chronicle or any of the many other journals which deal with British horticulture, will recognize here the names of the most distinguished English plantmen and growers. Hilliers, had four separate exhibits, Will Ingwersen, who never misses an issue of Gardeners Chronicle, had a superb display of alpine and other species, four growers showed cacti and succulents, H. J. Welch (the author of a recent book on dwarf conifers) had a fine exhibit of these popular plants, at least three firms showed rock garden plants and there were exhibits of orchids, bromeliads, begonias, aroids, geraniums, saxifrages, delphinium, ferns and almost any group of ornamental plants which could conceivably be called to mind.



Fig. 41 Rock garden at Edinburgh

Outside the central marquis were several garden arrangements, chief among which was the excellent exhibit staged by the Royal Horticultural Society at Wisley which we were to visit a few days later.

THE CHELSEA PHYSIC GARDEN

Ever since I started lecturing on the History of Botany many years ago I have been aware of the importance of the Chelsea Physic Garden, established in 1673 (and therefore the second oldest garden in England) and centered in the very heart of London. Fortunately, for the first time in many trips I had arranged before-hand to visit it and to take with me those members of our party who were interested in seeing this remarkable oasis on the very banks of the Thames.

It was a very special privilege for us to be welcomed by the Curator, Mr. W. G. MacKenzie, who graciously conducted us around the four acres of this historic garden, pointing out the many interesting trees, shrubs and herbaceous plants which comprise its collections. Dominating the scene was a statue of Sir Hans Sloane, whose name is so intimately connected with the history of this garden and whose writings on Madeira and the West Indies are so well known to every student of the flora of the New World (Fig. 38).

Since one of the functions of this garden is to supply teaching material in the form of living plants, it was not surprising to find that most of the herbaceous plants are arranged in systematic or family sequence. In addition to these groupings, there were many isolated specimens of great interest to us, including the spectacular *Cytisus Battaudieri* from Morocco which to date we have not succeeded in growing in the Philadelphia area and *Abutilon vitifolium*, a native of Chile, which we had earlier seen in Dublin



Fig. 42 Scree garden at Glasgow

(where it was first introduced) but which was now in full bloom with its beautiful pale purplish-blue flowers.

Although the skies, as usual, were heavily overcast I venture to hope that I obtained at least one or two pictures of the Chelsea Physic Garden which I can use in future lectures on the age old relationship between Botany and Medicine. For here is another of those important gardens (like those of Pisa, Padua, Bologna, Montpelier, Madrid, etc.) in which prospective physicians were required to learn the plants, which they were to utilize in the practice of their profession.

CAMBRIDGE

Having seen Oxford, it seemed only fair that we should visit her great sister university. Accordingly on May 26 (a day which dawned without the trace of a cloud) we set forth on the 60-mile drive to Cambridge. It began to rain shortly after we entered the University Botanic Garden, cleared while we were having lunch at the Royal Cambridge Hotel and developed into such a prolonged and severe electric storm in the afternoon that our visit to the famous colleges and their "backs" was greatly curtailed and we had to cancel our trip to Ely Cathedral.

Our good friend, John Gilmour, the Director of the Garden was indisposed, but he kindly arranged for Mr. Robert Younger and Mr. Peter Orriss to meet us and show us around. This garden, which was founded in 1760, originally consisted of only 5 acres. In 1840 it was moved to its present site and consists of 40 acres, some 20 of which are under intensive cultivation.

One of the most interesting features of the grounds is a recently constructed rock garden (Fig. 39) in which different types of stone are used and the plants are arranged according to their geographic origin. Sections were devoted to plants from different ecological areas in the British Isles, others to alpine species from various European countries; one contained plants from the Americas and another species indigenous to Australia and New Zealand, and so on.

One portion of the garden assigned to shrubs included such "old friends" as *Eccremocarpus* and *Fabiana*, plus a number of newcomers including *Clianthus punicens*, from Australia, and *Petteria ramentacea*, a Leguminous shrub from Dalmatia and Montenegro. I was especially pleased to see a sturdy plant of *Sinowilsonia Henryi*, a member of the Hamamelidaceae which we have long been attempting to obtain for the Witch-hazel collection at the Morris Arboretum.



Fig. 43 A portion of the garden at Ascreavie

Another unique feature of this garden is the section in which plants are arranged according to the dates of their introduction into horticulture. This chronological grouping provides a dramatic record of plant exploration over a period of several centuries.

I recalled that in Bean's indispensable "Trees and Shrubs hardy in the British Isles" the author states that the only good specimen of *Pinus Gerardiana* in England is in the Cambridge Botanic Garden. I asked to be shown this tree and, which is now about 30 feet tall, and was surprised to note that in its peeling bark it resembles the lace-bark pine (*P. Bungeana*) ; its cones, however, are much larger. Not far from this tree was an impressive specimen of the one-needle pine (*P. cembroides* var. *monophylla*) in which most of the leaves were really entire, instead of being split in two as is so often the case.

Since an important function of this garden is to supply teaching material for the University there are, as at Cork and Oxford, systematic beds containing herbaceous representations of the important families of flowering plants.

Dr. Gilmour is certainly to be congratulated on the immense progress he has achieved in this garden.

WISLEY

Saturday, May 27, was to be our day at the Gardens of the Royal Horticultural Society at Wisley, but due to inclement weather our visit was reduced to half a day. We were met at the entrance by Mr. Frank P. Knight, the Director, who spent the entire morning with us.

Wisley consists of some 300 acres of which approximately half are made up of the Garden and the Vegetable Trials. There are greenhouses, laboratories and offices, for Wisley performs a variety of functions: it is a test garden, it con-

ducts research in horticulture and it trains young gardeners in the theory and practice of horticulture. In the latter connection it is worthy of note that a former superintendent of the Morris Arboretum was a graduate of Wisley.

Among the first plants to greet us as we walked past the laboratory were *Acacia dealbata* (hardy here in protected situations), several species of *Ceanothus*, *Clematis montana*, and the golden-flowered *Fremontia californica*, a member of the Sterculiaceae.

Our walk led us through a succession of perennial borders and past a wooded area, replete with native and introduced herbaceous plants. One of the most intriguing specialties here was the huge and ungainly *Lilium (Cardiocrinum) giganteum*, a native of the Himalayas. At last we came to the Rock Garden. We saw many fine rock gardens on our tour, but the interesting feature of the one at Wisley is that, because it has been laid out on a natural slope, almost the entire garden can be seen at a glance (Fig. 40). By this time we had become familiar with many of the alpine genera (*Saxifraga*, *Primula*, *Gentiana*, *Aethionema*, *Armeria*, *Iberis*, *Aurinia*, etc.) which are grown in Britain, but here they flourished so profusely as to excite repeated exclamations of wonder. As Philadelphians, we were pleased to see a plant of *Tiarella Wherryi*, named for our friend Dr. E. T. Wherry.

Mr. Knight took us through a small but very choice alpine house, where many rare and fascinating plants are grown in containers, and then showed us a number of "sink gardens". These are collections of plants grown in the type of stone kitchen sinks used in houses built centuries ago.

Wisley is, of course, famous for its vast collection of azaleas and rhododendrons, most of which are concentrated on Battleston Hill, and as we walked through acres of these trial plantings the effect even in the rain was dazzling.

Many interesting trees are also grown in this area and include a wide variety of *Prunus*, *Sorbus* and *Magnolia*. It was disappointing to be too late for *M. Campbellii*, but we were told that it had been badly damaged by cold weather this year.

A section composed of raised peat beds contains such unusual genera as *Soldanella*, *Cassiope*, *Phyllodoce* and *Shortia*, as well as a number of species of *Meconopsis*, *Lilium*, and *Primula*.

The Heath Garden at Wisley merits a day in itself and, although we are rather proud of our own small collection at the Morris Arboretum,

we were compelled to admit that southern England provides far better conditions for growing heaths and heathers than does Philadelphia.

It is greatly to be regretted that we saw so little of Wisley, but certainly the memory of what we did see will long linger with us.

Sunday morning, May 28, was an interval of leisure and in mid-afternoon we flew from London to Edinburgh for the final three days of our tour.

The following morning was devoted to a sightseeing tour which included Edinburgh Castle, St. Giles' Cathedral, the "Royal Mile", Holyrood Palace and of course, the statue of Greyfriar's Bobby!

EDINBURGH GARDEN

After lunch we repaired to the Royal Botanic Garden where we were welcomed by Dr. Harold R. Fletcher, the Regius Keeper. Although only about 60 acres in extent, this famous garden contains an extraordinarily rich collection of plants from all the temperate regions of the world.

After conducting us through extensive plantings of rhododendrons, deciduous trees and colorful mixed borders (where, again *Meconopsis* was a thing of dazzling beauty, with both blue and yellow-flowered species and hybrids), Dr. Fletcher brought us out in full view of the rock garden and then wisely left us to wander around at will in this largest (over 4 acres) and most renowned of all the rock gardens in the world (Fig. 41). Indeed the only collection of hardy alpine plants with which it might be compared is that at the Nymphenburg Gardens in Munich, where many members of our party had been with us in the spring of 1964.

Another salient feature of this rock garden is the important role that it has played in the introduction and testing of alpine plants from all over the world. It has thus been a major source for supplying plant material to a host of other gardens and arboreta.

The plants here are well and conspicuously labeled and we were able to put names on many things which we had seen elsewhere, but had been unable to identify. One of these was the genus *Ourisia*, a member of the Scrophulariaceae from the Southern Hemisphere. An attractive shrubby *Senecio* with grey-green foliage, which we had been seeing everywhere, was now revealed as *S. Greyi*. And so it went with plant after plant. As might be expected, the collection

was rich in Ericaceae, especially dwarf and low-growing forms of *Rhododendron* and we saw again here the *R. Williamsianum* that had so intrigued us at Bodnant.

The Edinburgh Garden is so overshadowed by the reputation of its rock garden that one tends to forget that it contains 17 greenhouses (including a magnificent palm house) hedge collections, trial beds and numerous other features, including a fine gallery of modern art.

We were shown the new greenhouse unit, still under construction, which sounds a completely new note in greenhouse design. It will be 60 feet in width, 425 feet long, and, by virtue of a series of outside lateral supports, will not have a single interior pillar or column.

This was the third and last of our completely clear, showerless days.

Tuesday, May 30, was one of the fullest days on our schedule. Leaving our hotel in Edinburgh at 8:30, we drove along the banks of the River Forth through Falkirk to Stirling, where we caught a glimpse of the famous castle from a distance. From Stirling we proceeded through hilly country to Callander where a stop was arranged both for the purchase of woolen goods at one of Scotland's best known mills and for lunch at the Ancaster Arms Hotel.

Following lunch we drove through the beautiful Trossachs area, with views of Loch Venacher, Loch Katrine and — most renowned of all — Loch Lomond. Our way then led through Dunbarton to Glasgow where we put in a belated arrival at the Botanic Garden and were cordially received by the Curator, Mr. E. W. Curtis.

GLASGOW BOTANIC GARDEN

The one thing most of us had heard about these gardens was that they possessed a superior system of greenhouses. This was certainly no exaggeration, but the gardens contain several other fine features which entitle them to a high reputation. There is a small but excellent rock garden a scree collection (Fig. 42), mixed borders and a representative assortment of trees and shrubs. Since, however, our time was limited we devoted most of it to the greenhouses. The tropical fern house here was the largest and most exciting we had ever seen, with a remarkable wealth not only of ferns but of many other tropical groups of plants. One very ingeniously conceived and beautifully executed house was devoted to a demonstration of the important members of the plant kingdom, starting with the algae and fungi and moving on through the mosses and ferns to representative groups of higher plants. Separate

sections were devoted to begonias and orchids and a very special house contains the famous collection of filmy ferns (*Hymenophyllum* and *Trichomanes*) which of course, reminded many members of the party of the much smaller but very choice filmy fern grotto at the Morris Arboretum.

The morning of our final full day of the tour (May 31) was devoted to "leisure". For some this meant sightseeing, for others shopping, but for a few of the dedicated "Horts" (see Morris Arb. Bull. Vol. 17. 52-54, 1966) it meant a return to the Edinburgh Gardens for a more leisurely inspection which began under blue skies, which soon turned to grey.

Mostly we concentrated on the rock garden, and it was well that we did, for many plants which we had overlooked on our earlier visit now claimed our attention. Among these were various species of *Erica* (*E. mediterranea* and *E. arborea*), fine plants of *Viburnum Davidii* in full bloom, at least two species of the interesting Composite genus *Celmisia*, two species of *Leontopodium* (also a Composite), numerous kinds of *Hebe*, *Colletia infasta* (of the Rhamnaceae, a native of Chile) and a fascinating succession of dwarf or slow-growing conifers. One could certainly spend days or even weeks without exhausting the treasures of this unique collection.

ASCREAVIE

Following an early lunch we headed north through Perth to Kirriemuir to visit the private gardens of Major and Mrs. George Sherriff at Ascreavie. Major Sherriff had spent many years collecting plants in China, Tibet and the Himalayas, and his garden is a treasure-trove of rare and interesting plants brought back by him from these far corners of the world. His collections are particularly rich in species of *Primula* and *Meconopsis* but include countless other plants seldom seen elsewhere (Fig. 43). We were greatly intrigued by a beautiful blue-flowered *Corydalis* (*C. cashmeriana*), a lovely dwarf barberry (*Berberis coccinea*), as well as a tall fastigiate orange-flowered species (*B. linearifolia*).

In addition to letting us feast upon the wonders of his garden, Major Sherriff admitted us to his charming home, adorned with marvelous photographs taken on the roof of the world, and treated us to a Gargantuan Scottish "high tea". As we told him upon our departure, his reception of us served as a very fitting climax for our three week's visit to Ireland and the British Isles.

The following day we flew from Edinburgh to London where we emplaned via Pan American for Philadelphia and the fourth Morris Arboretum Garden Tour came to an end.

Associates' Corner

FAREWELL TO THE PRESENT ADVISORY COUNCIL

The Advisory Council of the Morris Arboretum started ten years ago under very happy auspices and has so continued ever since.

Dr. Fogg and Mrs. Rivinus were lunching together, when Dr. Fogg suggested having an Advisory Council to meet at the call of the Director to render advice and other assistance as deemed necessary. Incidentally, it was a very good lunch.

We made up a list of persons we thought would be interested. Everyone contacted accepted to serve with enthusiasm and they have been most loyal in response throughout the years. Committees were formed to cover various projects such as the Rock Wall Garden, Tropical Fern House, Wall Garden, Medicinal, Publications, Library and the creating of a group of shrubs, vines and ground covers etc.

To start the ball rolling we gave a party in the Morris House which included a tour of the grounds to which we invited the Associates. It was a perfect day and a most successful gather-

ing. We have since held meetings of the Council in Gates Hall to report progress and make future plans, which were most interesting and stimulating.

Now that the Arboretum is under a new regime, we felt it only fair to let Dr. Dahl have a free hand in appointing a new Council, if he so desired, so we gave ourselves a victorious farewell gala on May 3rd of this year, which was enjoyed by all. As Chairman of this Council, I want to thank the members for their consistent interest and cooperation.

To associate with such a congenial and friendly group, bonded as we are by our love of the Arboretum, has been a wonderful privilege, especially under the exciting leadership of Dr. Fogg.

I am sure we all have gained by our experiences and have many happy memories.

MARION W. RIVINUS
Chairman

Arboretum Activities

(Continued from Page 26)

created will be filled with recently acquired cultivars of *Calluna* and *Erica*. Near the Dwarf Conifers, an interesting experimental planting of New Zealanders (*Hebe*), which thrive so ornamenteally in the San Francisco region, has been recently completed.

THE STAFF

On April 4 Dr. Fogg gave an illustrated lecture on "The History of Botanical Gardens" to the Main Line Seminar in the Wedgewood Museum at Merion and on April 13 he spoke on "The Trees of Fairmount Park" to the Merion Garden Club. From April 27 to 29 Dr. and Mrs. Fogg led some 38 persons on a three-day bus trip to the Glenn Dale Plant Introduction Station, the U. S. National Arboretum and the Kingsville Nurseries, Kingsville, Maryland and between May 11 and June 1 they conducted the 1967 Morris Arboretum Garden Tour to Ireland, Wales, England and Scotland. An account of the latter tour will be found elsewhere in this issue.

Dr. Patricia Allison presented an illustrated lecture on the mushrooms of the Wissahickon and related fungi at the Annual Meeting of the "Friends of the Wissahickon" on May 23, 1967. Earlier in the month she spoke to the Manhattan section of the Electro-Chemical Society about her experiences in Ecuador.

Dr. Hui-Lin Li has recently received a grant from NIH in support of his research, in collaboration with Dr. J. J. Willaman, on "Alkaloid Plants." Dr. F. S. Santamour, Jr. presented a seminar at the Institute of Forest Genetics in Berkeley, California.

On May 2, 1967, Dr. A. Orville Dahl took up his duties as the new Director of the Morris Arboretum. At Dr. Fogg's invitation he presented a lecture and film on his Biosatellite research project, being conducted in collaboration with Dr. A. H. Brown, before the Faculty Research Club of the University of Pennsylvania on May 5, 1967.

The Philadelphia Chapter of the National Association of Gardeners, with Mr. John Dourley presiding as Chapter President, held their meeting on 8 June at the Arboretum. Dr. Dahl had the pleasure of addressing the group on "Exotic plants in the Far North." In recognition of meritorious service, Mr. Dourley was presented with the silver pin of the organization.

Plant Distribution days, 26 and 27 of May, proved, indeed, to be a novel experience. In excess of 600 plants were distributed, including such varieties as: *Magoulia acuminata*, *Buddleia alternifolia*, *Elaeagnus pungens*, *Acacia floribunda*, *Juniperus chinensis Pfitzeriana* cv. "Blue Cloud", *Thuja plicata* and *Erica arborea alba*. We trust they will give pleasure in their new habitats.

FREDERICK W. SCHWOEBEL

Just as this issue goes to press we learn with deep regret of the death on June 24 of Mr. Frederick W. Schwoebel, who for 15 years had served as Curator of the Arboretum's Langstroth Bee Garden. An appreciation of Mr. Schwoebel's contribution to this Garden will appear in a future issue.

A. O. D.

New Associates

The Arboretum is happy to welcome the following new Associates who have been enrolled since March, 1967:

Mr. Curtis H. Clement

Mother Mary Charlotte

Mrs. Lewis C. Clark

Mr. and Mrs. P. R. L. Sexton

Mr. Sol Freedman

Mrs. Lowell S. Thomas

Mrs. Shirlee S. Kushner

Mrs. Melicent E. Turner

Mr. Carl J. Malisheski

Mrs. Andrew B. Young

Anthocyanins in Spruce Foliage

FRANK S. SANTAMOUR, JR.

ABSTRACT

The primary anthocyanin in the rarely-observed transient spring pigmentation of spruce needles was found to be cyanidin 3-glucoside. Among several species and hybrids, delphinidin 3-glucoside was found only in one of six hybrids of *Picea glauca* × *jezoensis hondoensis*. Galls caused by *Adelges abietis* were pigmented only with the cyanidin glucoside. This is presumed to be the first identification of anthocyanins in the foliage of a gymnosperm.

Among the gymnosperms, and in particular the Pinaceae, anthocyanin production is largely confined to the reproductive structures. Santamour (1966 b) has recently reported the existence of the 3-glucosides of cyanidin and delphinidin in the male and female conelets of 35 species of six genera of the Pinaceae. In addition, Santamour (1966 a) identified cyanidin 3-rhamnoside in male conelets of several species of *Chamaecyparis* (Cupressaceae).

Many species of woody angiosperms, on the other hand, show more conspicuous anthocyanin pigmentation in the leaves than in the flowers. This is especially true among those genera which are the most important shade, street, and ornamental trees. In some species the most striking coloration occurs in the autumn when many maples, gums, and dogwoods are ablaze with color. In still other species, cultivars have been selected that show a more or less continuous anthocyanin pigmentation of the leaves during the growing season. Two of the most popular trees of this type are *Fagus sylvatica* L. 'Atropunicea', the copper beech, and the 'Schwedleri' and other cultivars of the Norway maple, *Acer platanoides* L. Types such as these seldom exhibit much fall coloration.

However, the most prevalent type of anthocyanin pigmentation in leaves is also the most inconspicuous. That is the transient coloration present in very young leaves either shortly after growth has started in the spring or in any new growth throughout the year. Anthocyanins can be detected in a majority of broadleaf trees at this time, with even the plane trees, lindens, and hollies showing some pigmentation. Most of the species exhibiting transient spring coloration show no fall color, nor have they produced any permanently-colored cultivars.

The cause of transient leaf coloration in the spring is thought to be an excess of sugars over the amount which is necessary or capable of being utilized during the early stages of growth. These same factors of carbohydrate availability and utilization are also apparently operative in the "evergreen" conifers but anthocyanin pig-

ments have seldom been reported in conifer foliage. Harborne (1966) referred to a paper by Beale *et al* (1941) as having reported on pigments in the needles of *Picea obovata* Ledeb. However, no mention of needle pigments could be found in the latter work, although it was determined that the male conelets of *P. obovata* contained a cyanidin 3-monoside. In the same paper, Harbone (1966) stated "There is still some question as to whether anthocyanins occur in gymnosperms." Although published in 1966, this paper was originally given at a meeting in April, 1965, before the more recent work on conifer anthocyanins had been published.

During the spring of 1967, reddish pigmentation was noted in young needles of several species and hybrids of *Picea* (spruce) at the Morris Arboretum. The information reported below is, to the best of our knowledge, the first identification of anthocyanin pigments in the foliage of any gymnosperm.

MATERIALS AND METHODS

The spruce trees used in this study were derived from the hybridization work of the U. S. Forest Service, and were recently evaluated by Santamour (1967). The 151 trees of this group include six species or intraspecific combinations and some nine interspecific hybrids involving 10 species. In the spring of 1967, the trees were just beginning their tenth growing season from seed.

Needle pigmentation was noted in *P. glauca* (1 tree), *P. montigena* Mast. (1 tree), *P. glauca* × *jezoensis hondoensis* (6 trees), *P. Abies* × *montigena* (1 tree), *P. montigena* × *Abies* (1 tree), and *P. montigena* × *asperata* (1 tree). On May 29, 1967, the extent of the pigmentation ranged from one-half the needle length (5-6 mm.) in some individuals to only the distal 1 mm. in others. In all trees except those of *P. glauca* × *jezoensis hondoensis*, coloration was confined to the leader and new laterals at the top of the tree. In the above hybrid, some primary laterals of three or even four years of age showed color in the new growth. As stem and needle elongation continued, the extent and intensity of pigmenta-

tion diminished until on June 20, 1967, there was no evidence of color to the naked eye. It is not known whether the marked needle pigmentation observed in 1967 primarily resulted from or was merely accentuated by the long period of cool and wet spring weather.

Pigmented portions of the needles were removed and extracted in cold methanolic 1% HCl. Preliminary chromatograms of the extracts were run on Whatman No. 3 MM chromatography paper using BAW (butanol-acetic acid-water, 4:1:5, upper phase) in ascending development. After banding and elution, the purified pigments were chromatographed again in BAW, as well as 1% HCl (water - conc. HCl, 97:3) and Bu HCl (butanol - 2N HCl, 1:1, upper phase) on Whatman No. 1 paper. The pigments were hydrolyzed in 2N HCl for 40 minutes and the aglycone was purified and extracted according to the method of Geissman (1955). Aglycones were chromatographed in Forestal solvent (acetic-acid - conc. HCl - water, 30:3:10). Sugars were extracted and analyzed following Harborne (1960).

The absorption spectra of the purified pigments were examined with both a Bausch & Lomb Spectronic '20' and a Carey Model 14 spectrophotometer. Harborne (1958) has given spectral data for many anthocyanins.

RESULTS AND DISCUSSION

The primary anthocyanin was, as in the conelets, cyanidin 3-glucoside (R_f 0.37, 0.07, 0.25, λ_{max} 525 mu)¹. This pigment was the sole anthocyanin of all trees except one individual of *P. glauca* \times *jezoensis houdensis*. The six trees of this hybrid combination were derived from three different female parents with the same tree as the source of pollen. Only one of the three original trees of seedlot Pc-539 had survived until 1967, and colored needle tips of this tree showed equal proportions of cyanidin 3-glucoside and delphinidin 3-glucoside (R_f 0.28, 0.03, 0.10, λ_{max} 535 mu).¹

¹ Rf values in BAW, 1% HCl, Bu HCl; absorption maximum in visible spectrum.

The new growth of this same tree was attacked in 1967 by the spruce gall adelges or "aphid", *Adelges abietis* (L.). The bases of the needles involved in the gall area were highly colored and there was a red line around the closed mouths of each cell of the gall. Galls were found on new shoots irrespective of their needle pigmentation pattern, but the only anthocyanin found in the galls was cyanidin 3-glucoside.

In view of the distribution pattern of the delphinidin glucoside, it would have been of interest to investigate the pigments of the parent trees. Unfortunately, it was not possible to locate precisely the specimens of *Picea glauca*, although an examination of several mature trees revealed no anthocyanin pigments in the new growth at the top of the tree. The leader of the single mature individual of *P. jezoensis hondensis* was pigmented but could not be sacrificed for analysis. No pigmentation was noted in the new growth of several other species including *P. montigena*. While it appears that certain species or genotypes are more likely to exhibit transient spring pigmentation of the foliage, the tendency is probably enhanced both by the youth of the plant and by weather conditions.

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A Key To The Cultivated Maples

EDWARD MURRAY

This key has been prepared to help facilitate the identification of the maples which are cultivated in temperate North America and Europe, particularly those which may be grown in greater Philadelphia. Although the genus *Acer* contains more than one hundred species, only about sixty are commonly cultivated.

No attempt is made in this key to include the interesting cultivars and forms of such polymorphic species as *A. palmatum*, *A. Platanoides*, or *A. Pseudo-Platanus*. Although fruit and bark often furnish valuable diagnostic characters and are occasionally mentioned, the present key is based primarily upon the foliage.

Acknowledgment is made to Dr. Theodore R. Dudley and Mr. Peter S. Green who aided this study while the author enjoyed a Mercer Fellowship at the Arnold Arboretum. Valuable assistance has been rendered by Professor Robert B. Clark while at Rutgers University and by my adviser, Professor Robert P. Meahl, of the Pennsylvania State University. Especial thanks are due Dr. John M. Fogg, Jr., Director Emeritus of the Morris Arboretum, who encouraged the preparation of this key. Dr. Dudley, presently of the U. S. National Arboretum in Washington, D. C., helped with further recent suggestions for improvement.

1. Leaves compound. (divided to the base into leaflets).
 2. Leaflets 4 to 5 or more.
 3. Leaves pinnate, leaflets 3 to 13.
 3. Leaves palmate, leaflets 4 to 7, rarely more.
 4. Leaflets entire, willow-like, silvery-grey beneath.
 4. Leaflets pinnatifid, fern-like, green or red beneath.

A. *Negundo*

2. Leaflets always 3.
 5. Margins of leaflets entirely smooth, (rarely serrate).
 6. Leaflets with 10 to 12 main vein pairs; always 3-foliolate; lateral leaflets symmetrical; fruit pedicels 1–5 mm. long.
 6. Leaflets with 7 to 9 main vein pairs; frequently 5-7-foliolate; lateral leaflets asymmetrical; fruit pedicels 10–20 mm. long.

A. *Henryi*

5. Margins of leaflets distinctly serrate, or sinuate-ciliate.
 7. Lateral leaflets symmetrical, glabrescent; petioles glabrescent.
 8. Leaflets ovate to rhombic, sharply incised with teeth 2–10 mm.
 9. Leaves simply-dentate, always 3-foliolate; racemes 10–15 cm. long.
 9. Leaves doubly-serrate, mostly 3-lobed to 3-foliolate; corymbs 2–4 cm. long.

A. *cissifolium*
A. *glabrum*
var. *neo-mexicanum*
A. *mandshuricum*

8. Leaflets ovate to rhombic, sharply incised with teeth 2–10 mm.
 7. Lateral leaflets asymmetrical, villous or pubescent to glabrescent; petioles villous or pubescent to glabrescent.
 10. Blades beneath and petioles glabrescent or pubescent; infructescence a many-fruited raceme.
 10. Blades beneath and petioles villous; infructescence a three- to five-fruited fascicle.
 11. Leaflets sinuate-ciliate and rarely toothed; bark smooth grey.
 11. Leaflets large-toothed to dentate; bark peeling either reddish or yellowish.
 12. Margins of leaflets incised to lobulate; blades silvery beneath with veins densely grey-villous; bark peeling red.
 12. Margins of leaflets irregularly dentate; blades green beneath with veins sparsely brown-villous; bark peeling yellow-brown.

A. *Negundo*

1. Leaves simple, but frequently deeply lobed or dissected.
 13. Main lateral leaf-veins straight and parallel, like *Carpinus* or *Ulmus*.
 13. Main lateral leaf-veins palmate or pinnate and curving.
 14. Leaves deeply dissected over $\frac{3}{4}$ ths deep, rarely into leaflets.
 15. Blades trifoliate.
 15. Blades 5–13-lobed, never 3-foliolate, some multifid.
 16. Petioles 1.5–4 cm. long; leaves 7–13-lobed; mature trees 2–5 m. tall; flowers with red petals; samaras 1.5–2.5 cm. long.

A. *nikoënse*
A. *griseum*
A. *triflorum*
A. *carpinifolium*
A. *glabrum*

17. Leaf petioles hairy; main leaf lobes 2–3 cm. wide; vein-axils tufted-hairy beneath.
17. Leaf petioles glabrescent; main leaf lobes under 2 cm. wide; vein-axils glabrescent beneath.
16. Petioles 3–15 cm. long; leaves 5-lobed (rarely 3- or 7-lobed); mature trees 10–20 m. tall; flowers with green petals, or with red sepals and apetalous; samaras 3–5 cm. long.
18. Leaves silvery and glabrescent beneath; flowers apetalous with red sepals; twigs slender, pliable.
18. Leaves light-green beneath, often tufted-hairy in vein-axils; flowers with greenish petals and sepals; twigs stout, stiff.
19. Tips of leaf-lobes acuminate; leaves pinnatifid; twin samaras alike; petiole sap milky.
19. Tips of leaf-lobes acute; leaves simply-lobed; twin samaras unequal; petiole sap clear.
14. Leaves mostly lobed less than 3/4ths, or unlobed.
20. Blades unlobed.
21. Leaves silvery beneath, evergreen, mostly entire (rarely lobed with mucros).
21. Leaves green beneath, deciduous, margins always toothed.
22. Blades cordate, 5–12 cm. wide, margins serrulate.
22. Blades lanceolate to ovate, 3–5 cm. wide, margins serrate to doubly-denticulate.
23. Leaves broadly ovate, glabrescent to canescent along veins beneath; inflorescence a panicle; samaras with wings at 30°–75° to connivent.
23. Leaves lanceolate to rhombic-ovate, densely pubescent to glabrous or rufous-tomentose in vein-axils beneath; inflorescence a corymb or raceme; samaras diverge at 40° to 150°.
24. Blades rufous-tomentose in vein-axils beneath (rarely naked); leaves lanceolate, serrate, 6–10 cm. long; inflorescence a raceme; samaras diverge 120°–150°.
24. Blades canescent to glabrescent beneath; leaves rhombic-ovate, doubly-denticulate, 4–6 cm. long; inflorescence a corymb; samaras diverge 40°–100°.
20. Blades lobed.
25. Leaves trilobed, entire to finely serrulate.
26. Lateral leaf-lobes diverge below the middle at a 45°–80° angle; pedicels 20–30 mm. long; corymb simple.
26. Lateral leaf-lobes diverge above the middle at a 30°–45° angle; pedicels 5–10 mm. long; corymb compound.
25. Leaves multi-lobed, toothed or entire (if trilobed, then serrate).
27. Margins of leaves ciliate.
28. Secondary leaf-lobes acute; samaras connivent to acute; inflorescence lateral.
28. Secondary leaf-lobes rounded; samaras horizontal; inflorescence terminal.
27. Margins of leaves not ciliate.
29. Leaves silvery beneath.
30. Leaf-lobes triangular; infructescence fasciculate.
31. Leaf-sinuses acute, open, to halfway deep; flowers with red petals; samaras acute-angled, 1–2 cm. long.
31. Leaf-sinuses rounded, often horse-shoe shaped, mostly over halfway deep; flowers apetalous with pinkish sepals; samaras obtuse-angled, 3–5 cm. long.
30. Leaf-lobes ovate; infructescence paniculate-racemose.
29. Leaves green or reddish beneath, not silvery.
32. Sinuses of leaf-lobes rounded or broadly "U"-shaped, not closing.
33. Leaves lobed 3/4ths to 2/3rds deep, mostly 15 cm. to often 25 cm. broad; samaras with stinging hairs; petiole sap milky.
33. Leaves lobed to halfway deep, rarely more, mostly less than 15 cm. broad; samaras glabrous; petiole sap either clear or milky.
34. Leaves grey or yellowish beneath; samaras "U"-shaped to rarely divergent; inflorescence fasciculate; flowers apetalous; petiole sap clear, never milky.
35. Blades beneath grey or glaucous, often with appressed hairs.
36. Leaves 5–13 cm. long, averaging 10 cm.; leaf-tips acuminate.
36. Leaves 3–7 cm. long, averaging 5 cm.; leaf-tips obtuse to acute.
- A. japonicum*
cv. 'Aconitifolium'
- A. palmatum*
- A. saccharinum*
(Laciniatum Group)
- A. Platanoides*
f. *palmatifidum*
- A. Heldreichii*
- A. oblongum*
- A. distylium*
- A. tataricum*
- A. Davidii*
- A. stachyophyllum*
- A. monspessulanum*
- A. Bergerianum*
- A. diabolicum*
A. Miyabei
- A. rubrum*
- A. saccharinum*
A. Pseudo-Platanus
- A. macrophyllum*
- A. saccharum*
subsp. *saccharum*

37. Central lobes curved; basal lobes hastate, 1–2.5 cm. long.
37. Central lobes straight; basal lobes obtuse, 3–4 cm. long.
35. Blades beneath yellow-brown, often with erect hairs beneath.
38. Leaves 7–17 cm. long, averaging 10–13 cm.; stipules often present; twigs dull, mottled grey-brown; trees to 25 m.
38. Leaves 4–10 cm. long, averaging 7 cm.; without stipules; twigs lustrous, dark red-brown; trees to 10 m. tall.
34. Leaves lustrous to dull-green beneath; samaras horizontal to obtuse-angled; inflorescence corymbose; flowers with petals; petiole sap milky when young.
39. Primary leaf-lobes with secondary lobes acuminate; leaves dark green or purplish above and lustrous beneath.
40. Leaf-margins entire between lobes; samaras extrorsely falcate to nearly horizontal, 4–5 cm. long.
40. Leaf-margins finely serrulate-undulate between lobes; samaras diverge about 90°, up to 3 cm. long.
39. Primary leaf-lobes with secondary lobes rounded to acute, or primary lobes without secondary lobes.
41. Secondary leaf-lobes present; samaras horizontal to swept-back at an angle of 180° to 200°.
41. Secondary leaf-lobes absent; samaras obtuse-angled to connivent.
42. Leaf-lobes 3 to 5, never 7; leaf-bases rounded; secondary veins raised and very prominent beneath.
42. Leaf-lobes mostly 5 to 7; leaf-bases hastate to cordate; secondary veins not as prominent nor as raised as above.
43. Twigs dull grey-brown; leaf-bases truncate to cordate; samaras thick, 10–15 mm. wide.
43. Twigs glossy green and brown; leaf-bases sagittate to cordate; samaras thinner, 5–10 mm. wide.
44. Leaves mostly 7-lobed; samaras nearly horizontal to obtuse-angled, 2–4 cm. long and 8–10 mm. wide.
44. Leaves mostly 5-lobed; samaras connivent to acute-angled, mostly under 2.5 cm. long and 5–7 mm. wide.
32. Sinuses of leaf-lobes acute (often obtuse in *A. Opalus*, but not rounded).
45. Leaf-outline ovate to lanceolate; main lateral lobes from the base of the blade.
46. Leaves of non-fruтиng (or sterile) twigs mostly with several pairs of lateral lobes, often glabrescent beneath; leaves of fruiting twigs coarsely doubly-serrate, usually canescent overall beneath.
46. Leaves of both fruiting and non-fruтиng twigs mostly with one pair (rarely with two pairs) of lateral lobes; hairs chiefly along the veins beneath when present.
47. Blades green beneath, often canescent along the veins.
48. Leaves from 4–8 cm. long, mostly 6 cm., often canescent along veins beneath.
48. Leaves from 2–4 cm. long, mostly 3 cm., glabrescent beneath.
47. Blades grey or glaucous beneath, often rusty-tomentose in vein-axils beneath, or glabrous.
49. Leaf vein-axils rusty-tomentose beneath; samaras obtuse to erect, from 90° — 140°.
49. Leaf vein-axils glabrous beneath; samaras horizontal to diverging.
50. Leaf-lobing highly variable; leaf-bases cordate, rarely rounded; blades mostly 4–10 cm. long, averaging 6 cm.
50. Leaf-lobing consistently deep; leaf-bases truncate to cuneate, rarely cordate; blades mostly 2–4 cm. long, averaging 3 cm; the juvenile or sterile form.
45. Leaf-outline sub-orbicular; main lateral lobes usually above the middle of the blade.
51. Blades strongly 3-lobed, often with two weaker, basal lobules.
- A. saccharum*
subsp. *grandidentatum*
A. saccharum
subsp. *floridanum*
- A. saccharum*
subsp. *nigrum*
A. saccharum
subsp. *× leucoderme*
- A. Platanoides*
- A. truncatum*
- A. campestre*
- A. Lobelii*
- A. truncatum*
- A. cappadocicum*
- A. Mayrii*
- A. stachyophyllum*
- A. Ginuala*
- A. Semenovii*
- A. Maximowiczii*
- A. crataegifolium*
- A. Buergerianum*

52. Margins of leaves dentate-serrate, singly toothed and escalloped, often revolute when pressed dry, with main lobes roundish.
53. Leaves mostly 4–6 cm. long, greenish beneath; inflorescence a corymb; samaras under 3 cm. long.
53. Leaves mostly 7–17 cm. long, olive-green to grey or brownish beneath; inflorescence a paniculate-raceme; samaras 4–5 cm. long.
54. Blades 7–10 cm. long (rarely to 15 cm.); inflorescence 2–4 cm. wide, pendulous, with pedicels sub-sessile upon the rachis.
54. Blades 10–17 cm. long (rarely less than 10 cm.); inflorescence 4–6 cm. wide, erect, with pedicels 1–2 cm. from the rachis.
52. Margins of leaves serrate, often multipli-toothed, not escalloped, with main lobes acute to acuminate.
55. Leaves glabrous beneath, vein-axils glabrous.
55. Leaves beneath either tuberculate or hairy in vein-axils.
56. Blades coarsely serrate, mostly singly-toothed, pubescent below; inflorescence an erect raceme or a pendent corymb.
57. Leaf-tips attenuate-acuminate, leaves drooping, limber; inflorescence a pendulous corymb.
57. Leaf-tips acute to acuminate; leaves held aloft; inflorescence a long, erect raceme.
58. Leaf-lobes not prominent, 5–15 mm. deep, basal lobes weak, with grey hairs beneath.
58. Leaf-lobes prominent, 10–30 mm. deep, basal lobes strong, with light-brown to grey hairs beneath.
56. Blades finely serrate, mostly multipli-toothed, with either tubercles or hairs in vein-axils beneath; inflorescence a raceme.
59. Leaves strongly acuminate, with deep sinuses and lobes tending to overlap.
60. Blades much attenuated, tricuspidate; hairs red-brown in vein-axils beneath.
60. Blades acuminate, not attenuated, 5–7-cuspidate; hairs light-brown along veins and in vein-axils beneath.
59. Leaves weakly acuminate, with shallow sinuses which are open.
61. Blades mostly 5-lobed (rarely 3-lobed), acuminate, with rusty-brown hairs beneath; inflorescence a slender, erect panicle with a rusty-tomentose rachis.
61. Blades mostly 3-lobed (often with weak basal lobes), acute, with tubercles in vein-axils beneath; inflorescence a pendent raceme, with a glabrous rachis.
62. Lateral leaf-lobes at the middle of the blade; midribs and the petioles usually reddish.
62. Lateral leaf-lobes above the middle of the blade; midribs and the petioles mostly greenish.
63. Leaves mostly glabrous, lustrous green, often with pink midribs below.
64. Blades mostly 5-lobed, hexagonal, 8–15 cm. wide, with glabrous vein-axils.
64. Blades mostly 3-lobed, cordate-trilobate, 4–9 cm. wide, with brown-tufted to glabrous veins-axils.
63. Leaves either rufinerved and brown-green below, or usually glabrescent, dull-green below, often with brown midribs below.
65. Leaf-lobes often five, basally cordate, mostly rufinerved.
65. Leaf-lobes three, basally rounded, often with brown hairs scattered below.
51. Blades 5–7–multi-lobed, rarely 3-lobed with two basal lobules.

A. Opalus

A. Pseudo-Platanus

A. velutinum

A. glabrum

A. barbinerve

A. spicatum

A. ukurunduense

A. micranthum

A. Tschonoskii

A. nipponicum

A. capillipes

A. tegmentosum

A. Grosseri

A. rufinerve

A. pensylvanicum

66. Leaves mostly 5-lobed, prominently so.
 67. Margins of leaves coarsely dentate, blades greyish beneath; samaras reddish.
 67. Margins of leaves coarsely serrate to serrulate, blades green beneath; samaras greenish (or purplish in *A. Oliverianum*).
 68. Blades rusty-brown hairy beneath, mostly 8–15 cm. wide.
 68. Blades either glabrous or grey-hairy beneath, mostly under 10 cm.
 69. Leaves grey-hairy beneath, sinuses 1/3 to halfway deep; inflorescences on lateral twigs.
 69. Leaves glabrous beneath, sinuses halfway to 2/3rds deep; inflorescences on terminal twigs.
66. Leaves mostly 7–multi-lobed.
 70. Petioles and peduncles permanently pubescent.
 71. Second-year twigs reddish to greenish-brown; flowers greenish, inconspicuous, sepals greenish; samaras sub-horizontal.
 71. Second-year twigs lavender-grey to mauve; flowers reddish, showy, sepals garnet-red; samaras obtuse-angled at 120°.
 70. Petioles and peduncles quickly glabrescent or glabrous.
 72. Blades 9–13-lobed (rarely 7-lobed), dissected less than 1/3, mostly hairy-tufted in vein-axils beneath.
 73. Leaf-lobes 11–13, basal sinus closing (basal lobes often connivent).
 73. Leaf-lobes 9–11 (rarely 7), basal sinus open.
 74. Basal sinus of leaves usually "U"-shaped; samaras divergent at 120° to 160°.
 74. Basal sinus of leaves truncate to cordate; samaras horizontal.
 72. Blades 5–7-lobed (rarely 9-lobed), dissected usually half-way or more, mostly glaborous, some tufted-hairy beneath, very variable.
- A. Trautvetteri*
A. nipponicum
A. argutum
A. Oliverianum
A. Sieboldianum
A. Pseudo-Sieboldianum
A. Shirasawanum
A. japonicum
A. circinatum
A. palmatum

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Arboretum Activities

Woody plants flowering, or otherwise of ornament, in September are of interest in their potential contribution to prolonging enjoyable display in one's personal garden. Less common examples of species which are currently of ornament and interest in the Arboretum include: *Lespedeza Thunbergii* (DC.) Nakai, a graceful shrub from China with sprays of rose-purple flowers; *Pernettya mucronata* (L.) Gaud., a Chilean heath with rose-colored fruits; *Adina rubella* Hance with flowers tightly organized into picturesque globes about 1.2 centimeters in dia-

meter; and, of course, various hybrid roses of which I would note only one cultivar, the hybrid tea rose, "Duchess of Wellington", introduced in 1909 by A. Dickson and still providing generous display of elegantly fragrant, luscious buff-apricot flowers which begin as slender buds of graceful form. *Ceratostigma plumbaginoides* Bge., an herbaceous ally of an often woody genus, is all too-often overlooked for its fine and long production of striking deep blue flowers.

(Continued on Page 69)

Heaths and Heathers in Eastern North America

BARBARA H. EMERSON

Amchem Products, Inc.
Ambler, Pennsylvania

III. SUMMER-FLOWERING ERICA FORMS

Erica carnea L., *E. mediterranea* L., and their cultivars and hybrids develop conspicuous flower buds in late spring or early summer, but do not bloom until the following year after an extended rest. They are generally referred to as winter-flowering because that behavior does obtain and is unique. The flowering period of the so-called winter-bloomers is much longer than the term implies, often beginning in late fall and continuing until late spring. At the Morris Arboretum, the last two weeks of March and the first two or three in April constitute the major bloom period for most of this group of ericas. Their flowering during the winter months is relatively light. *Erica mediterranea* and a few other forms such as *E. carnea* 'Vivellii' do not flower at all until late April. With us, *Erica carnea* 'Praecox Rubra' justifies its name; it has been noted shedding pollen as early as October 26. A vigorous form of *E. carnea* being grown at the Arboretum under the name 'Winter Beauty' has an exceptionally long period of bloom. Its flowers begin to open early in November and continue to do so until nearly the end of May.

In late spring when the more conspicuous flowering of rhododendrons and a host of other ericads is at its peak, there is little heather bloom. This is the period, too, when the vivid coloring developed by the foliage of several forms of heather recedes. At this time of year, aesthetic interest in heathers is sustained by the fact that their foliage is evergreen, and by the variety of forms displayed. The tree heaths, *Erica arborea* L. and *E. australis* L., could add interest, but so far we have not been able to protect them adequately. They are killed or injured severely during the winter. Horticulturally, this is unfortunate because their tall upright habit is notable, and their profuse panicles of flowers in early spring would be particularly welcome.

From a botanist's standpoint, our inability to grow *Erica arborea* outdoors is even more regrettable, since it is the only species of *Erica* which occurs in both Europe and tropical East Africa, a link between the forms which grow in each of these areas. As a result of her intensive

investigations, Hansen (1950) has concluded that *E. arborea* is probably the most ancient species in the genus. She believes that for taxonomic classification of the Ericaceae, morphological shoot differences are of primary value. *E. arborea* flowers are arranged bi-axially on regular much-condensed foliar or scaly lateral shoots from the main axis of the current vegetative period.

In addition to East Africa, *Erica arborea* is well represented throughout the Mediterranean region, including the coast of Tunis, Algeria and Morocco, the Azores, and the coasts of Asia Minor. It is found throughout Italy, in Spain and Portugal, and in southern France where tobacco pipes are made from the roots and called "briar", a corruption of the vernacular name "la bruyère". Although Godwin (1956) records that *E. arborea* wood was found in a Roman well in Sussex, England, that is not sufficient evidence for considering the species was once native to the region.

Erica arborea 'Alpina', a variety from higher elevations, is hardier than the type. It was discovered in the Cuenca mountains of Spain in 1899, and seed was sent to Kew. Coats (1964) reported that one of the original plants was still thriving there in 1945, and had never been affected by cold. Although the variety does not grow as tall as the type, its upright habit and vivid green foliage make it a plant of great charm. At the Morris Arboretum it has not proved especially winter-hardy. Even with the protection of salt-marsh hay, injury has been serious enough that plants have not yet flowered. Plants grown by H. W. Copeland on Cape Cod have shown no winter injury.

Surprisingly, young plants of *Erica arborea* 'Alba' raised from seed sent by the Royal Botanic Garden in Edinburgh endured a temperature of at least -7° F in the winter of 1966-67 and sustained no more than tip burn. Most of the positions where the plants were set out were protected, but in one location they were exposed to considerable wind. Further observations of its winter-hardiness will be made on plants distributed to growers in several areas.

Ex-Superintendent John Dourley, who grew the above-mentioned form, also raised plants of *Erica australis* var. *aragonensis* Willk. from seed provided by Estacas Agronomica Nacional, Sacavem, Portugal. It was hoped that this sub-alpine form found in Portugal and northern Spain would also be fairly cold-resistant, but each winter it has been killed nearly to the ground. It resprouts from the basal portions, but has not flowered.

At the Morris Arboretum, therefore, of the heaths which flower in spring or summer on the current year's shoots, *Erica cinerea* L. is the first to blossom (Table 1). In an evolutionary chain of floral development proposed by Hansen, it is the link between *E. arborea* with inflorescences on secondary lateral shoots, *E. vagans* L. with much-condensed inflorescences arising directly from the main shoot, and the larger group of ericas with individual flowers borne on annual shoots, whether in the axils of leaves as *E. ciliaris* L., or condensed at the apex as with *E. Tetralix* L.

The bell heather, *Erica cinerea*, is unique among the European species of the genus. It has deep green leaves, glabrous except for minute cilia on the margins, but fine pubescence of the young branchlets creates a grey ash-like appearance that is apparently responsible for the specific epithet (Fig. 44). The short tightly-rolled leaves are in whorls of three's, and the species characteristically develops numerous short foliar shoots in the leaf axils of the annual shoot (Fig. 45). It is considered protogynous and the stigmas are evidently completely developed within the bud. Even so, in his comprehensive catalog, Letts (1966) lists 77 variants of this species as cultivars.

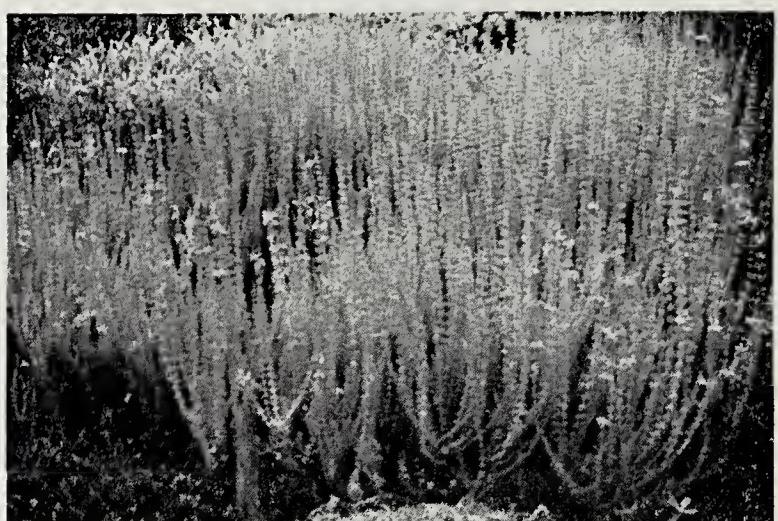


Fig. 45 *Erica cinerea* 'Golden Hue'

Exact identity of cultivars is always open to question, and this is aggravated when the basic stock plants for propagation must all be imported to the United States. In the case of heathers, nearly all the forms have been obtained from Great Britain, the Netherlands, Belgium, or Germany, although a few new variants have originated in the United States. Inevitably errors occur in spite of the greatest care, and are innocently compounded. This is especially true where there are few standards for comparison, as is the case here with heathers. Royal Horticultural Society trials at Wisley help clarify such problems, and a similar intent has been one motive in assembling the extensive collection of heather forms being grown in the Morris Arboretum garden. To this end, also, the Arboretum in cooperation with Roy J. Kersey of Devon, Penna., imported a large number of taxa as field-grown plants from British nurseries. Beside extending the range of cultivars being grown in the Philadelphia area, the direct importation will permit comparison with named forms already being grown by nurseries in this country and Canada.

There has been little deliberate hybridizing of heathers, most forms having been found in the wild or chosen from among open-pollinated seedlings in cultivation. Forms which seem distinct are often found, multiplied, and introduced by different growers under different names. Any serious grower is familiar with this situation and the resultant confusion. Accurate identification is often difficult until plants have matured enough to develop their characteristic growth habit. However, apparent discrepancies or duplications under different names will be noted as we continue observations. There have been instances of unintentional mis-labeling among the plants of *E. cinerea* obtained from American nurseries, but only two cases of really mistaken identity.



Fig. 44 *Erica cinerea* 'Golden Drop'

Some difficulty with growing *Erica cinerea* has been experienced at the Morris Arboretum, possibly because the soil is not sandy enough. Winter has produced little or no evidence of injury, but in summer plants may turn brown and die with little warning. Soil-borne fungus diseases such as *Phytophthora cinnamomi* or *Rhizoctonia* are suspect. Excessive soil moisture and heat apparently contribute to the difficulty. In the rainy summer of 1967, for the first time some similar difficulty was also experienced at Chatham, Massachusetts. Nevertheless, *E. cinerea* can be expected to persist in the East. At least four forms have recently been noted growing strongly (one plant in an open field was more than a meter wide) where they were planted about 20 years ago on Nantucket Island in a garden in which *E. carnea* and *E. Tetralix* are barely surviving. Of the several naturalized plants of *E. cinerea* Owen (1908) reported seeing on Nantucket, one found in 1868 lived for another 35 years.

Erica cinerea is widely distributed, not only within the British Isles, but in most of Western Europe. It ranges from Madeira to a latitude of $62^{\circ} 20'$ on the western coast of Norway, according to Grevilius and Kirchner (1923). Godwin notes that fossil leaves dating back about 7,000 years were found in western Ireland, and that apparently *E. cinerea* was also present in Suffolk, England, in the Neolithic period, before the Bronze Age.

Erica Tetralix, the cross-leaved heath, and its cultivars flower about the same time as *E. cinerea*, but have quite a different habit. Probably the commonest erica in Great Britain, in Europe it has a more northerly range than does the bell heather. The former grows in moors and bogs of northern Spain and Portugal, north-



Fig. 47 *Erica × Watsonii*

western Europe, along the coast of Norway to a latitude of $65^{\circ} 2'$, and sparingly across northern Germany to northwestern Poland. In the United States, it has been reported naturalized in Maine, Massachusetts, New Jersey, and West Virginia. It was once fairly common in a few locations on Nantucket, but has nearly disappeared. Probably it was introduced by human agency and eliminated by thoughtless collectors. Godwin finds the records of its presence in the late-glacial and post-glacial periods "of particular interest because of the pronouncedly oceanic West European character of its present distribution; it seems certain that its presence indicates that even in late-glacial time the British climate was oceanic."

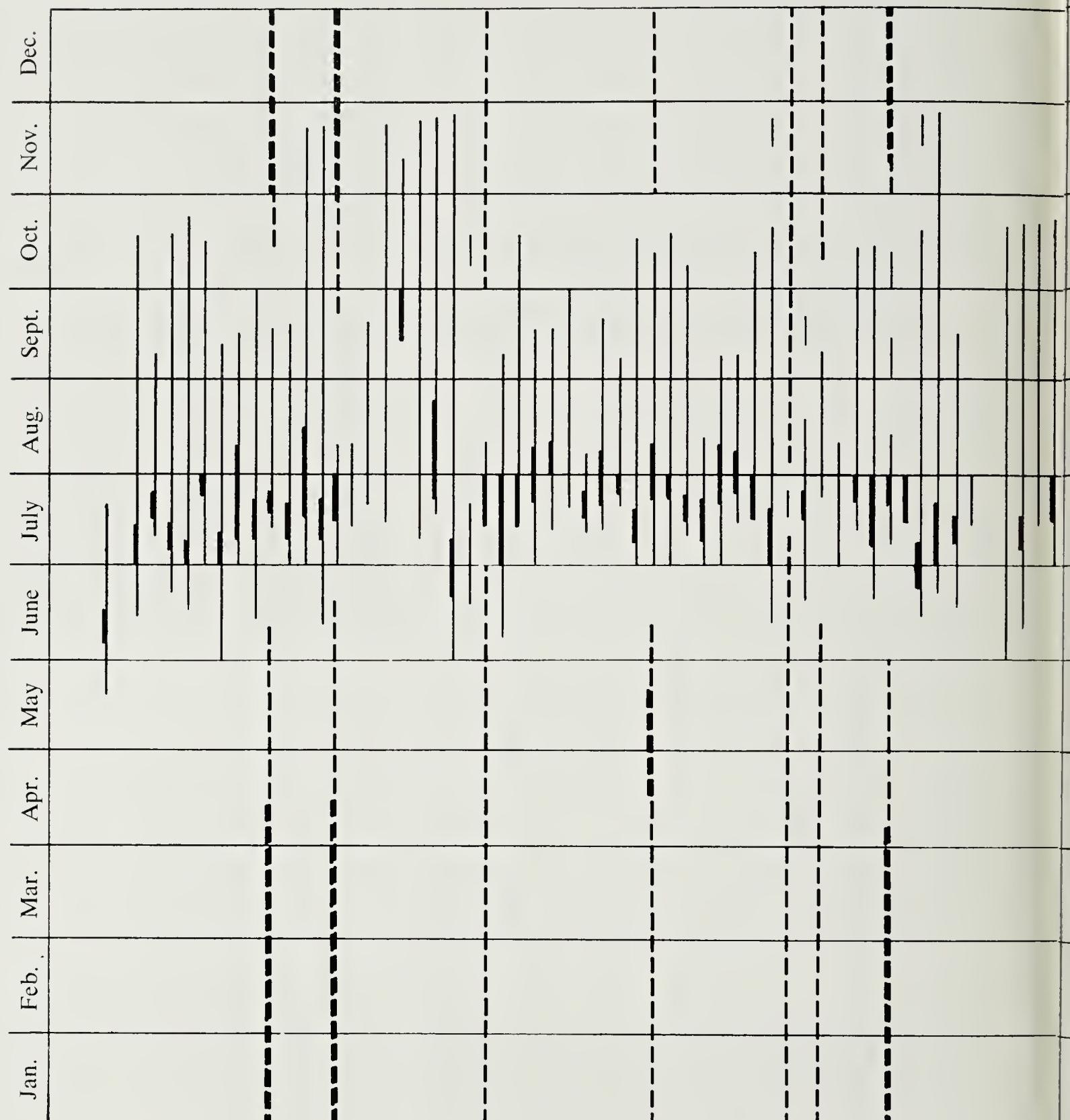
The inflorescence of *E. Tetralix* is a terminal umbel-like cluster of flowers on shoots produced the current year (Fig. 46). Branching is from the lower parts of the plant, which becomes quite bushy as growth progresses. Terminal growth of vegetative shoots is limited, and does not occur at all above the inflorescence. The pubescence of *E. Tetralix* varies somewhat in its nature, but is present in all the parts, often giving the plants a silvery appearance. The leaves, in whorls of four arranged cross-wise (suggesting its common name), are also ciliate, and the sepals leaflike but more hairy.



Fig. 46 *Erica Tetralix 'Alba Mollis'*

TABLE 1. THREE-YEAR BLOOM RECORD OF HEATHS AND HEATHERS AT THE MORRIS ARBORETUM

The solid lines represent the blooming period of each cultivar; the broken lines the period of foliage cover.
A heavy line indicates the period of maximum bloom or maximum foliage color.



Erica carnea 'Aurea'

'Carnea'
'Cecilia M. Beale'
'C. J. Backhouse'
'Gracilis'
'King George'
'Præcox Rubra'
'Ruby Glow'
'Sherwoodii'
'Snow Queen'
'Springwood Pink'
'Springwood White'
'Vivelli'
'Winter Beauty'

E. ciliaris
'Stoborough'

E. cinerea 'Alba'
'Attrubens'
'Atrosanguinea'
'C. D. Eason'
'Golden Drop'
'Golden Hue'
'Mrs. Dill'
'Mrs. G. Ford'
'P. S. Patrick'
'Splendens'

E. x 'Darleyensis'
'Arthur Johnson'
'George Rendall'

E. x 'Dawn'

E. Mackiana
'Plena'

E. mediterranea
'Brightness'
'W. T. Rackliff'

E. x 'Praegeri'

E. terminalis

E. Tetralix 'Alba'
'Alba Mollis'
'Con Underwood'
'Darleyensis'
'George Frazer'
'Rubra'
'Silver Bells'

E. vagans 'Alba'
'Carnea'
'Lyoneesa'
'Mrs. D. F. Maxwell'
'Nana'
'Pallida'
'Rosea'
'Rubra'
'St. Keverne'

E. x 'Watsonii'

E. x 'Williamsii'



Fig. 48 *Erica vagans* 'Superba Darleyensis'

Of the *Erica Tetralix* cultivars being grown at the Morris Arboretum, there is some question about the identity of 'Silver Bells'. Plants propagated as cv. 'Rubra' from cuttings originating at the Landbouwhogeschool in Wageningen have pale corollas (Nickerson 5 RP 8/5-6/10, light to deep purplish pink). It is assumed that they were confused with cuttings of 'Silver Bells' in the same shipment from the Netherlands. Field-grown plants of 'Silver Bells' from England have corollas of a deeper color (Nickerson 5 RP 5/10, moderate purplish red). True, there is considerable variation in color intensity among *E. Tetralix* seedlings, but this much discrepancy would not be expected in an asexually propagated cultivar.

There seems to be confusion in the trade between the *E. Tetralix* cultivars 'Alba' and 'Alba Mollis'. The latter is dwarfer in habit and more pubescent, thus soft to the touch as the name implies. Another form is being grown in this country in a very limited way under the tentative name of *E. Tetralix* 'Aurea'. It was bred by the late Esther Deutsch, and she considered it "possibly the best seedling I have . . . has golden tips and golden new growth all year . . . very dwarf . . . pure white flowers". So far, none of

the growers has noted golden growth in the sense of other 'Aurea' heather taxa with this characteristic. *Erica Tetralix* 'Alba' exhibits the same somewhat yellowed foliage at the tips of shoots, but it is masked by pubescence. The leaves of Mrs. Deutsch's seedling are pubescent only minutely, which may account for its appearance.

Erica Tetralix apparently hybridizes with other species. There are at least eight horticulturally important cultivars of hybrid nature which are assumed to have it as one of the parents. In four of the cases (*Erica* × 'Dawn', *E.* × 'Gwen', *E.* × 'H. Maxwell', and *E.* × 'Watsonii') *E. ciliaris* L. is assumed to be the other parent. *Erica vagans* seems likely as the second parent of the forms *E.* × 'Gwava' and *E.* × 'Williamsii'. *Erica* × 'Praegeri' is presumed to be a hybrid between *E. Tetralix* and *E. Mackiana* Bab., but is often listed as a cultivar of *E. Tetralix*.

In the Connemara area of Ireland, leaves dating back about 5,000 years and agreeing completely with *E. Mackiana* have been found on two occasions. Apparently, like *E. mediterranea*, this is one of a small group of Hiberno-Lusitanian species which may have arrived in Ireland in inter-glacial or very early post-glacial times, rather than by human introduction. *Erica Mackiana* was once considered to be a hybrid between *E. ciliaris* and *E. Tetralix* even though *E. ciliaris* is not found in Ireland. Then it was adjudged to be a variety of *E. Tetralix*. However, detailed examination of the leaf anatomy of all three forms (Smith, 1930) showed that for several reasons *E. Mackiana* is "certainly specifically distinct from *E. Tetralix* and is not a hybrid", being even more distinct than was suspected. A clear transverse wall in the epidermal cells of

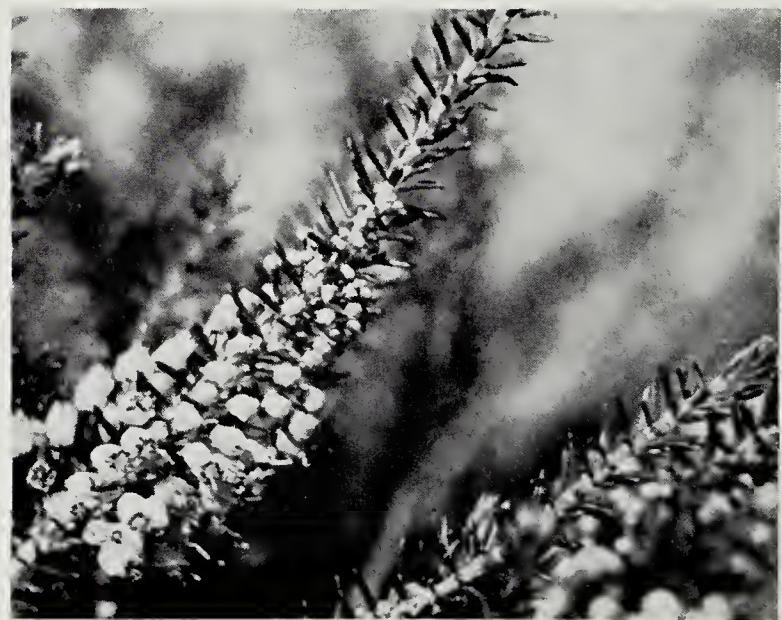


Fig. 49 *Erica vagans* 'Mrs. D. F. Maxwell'

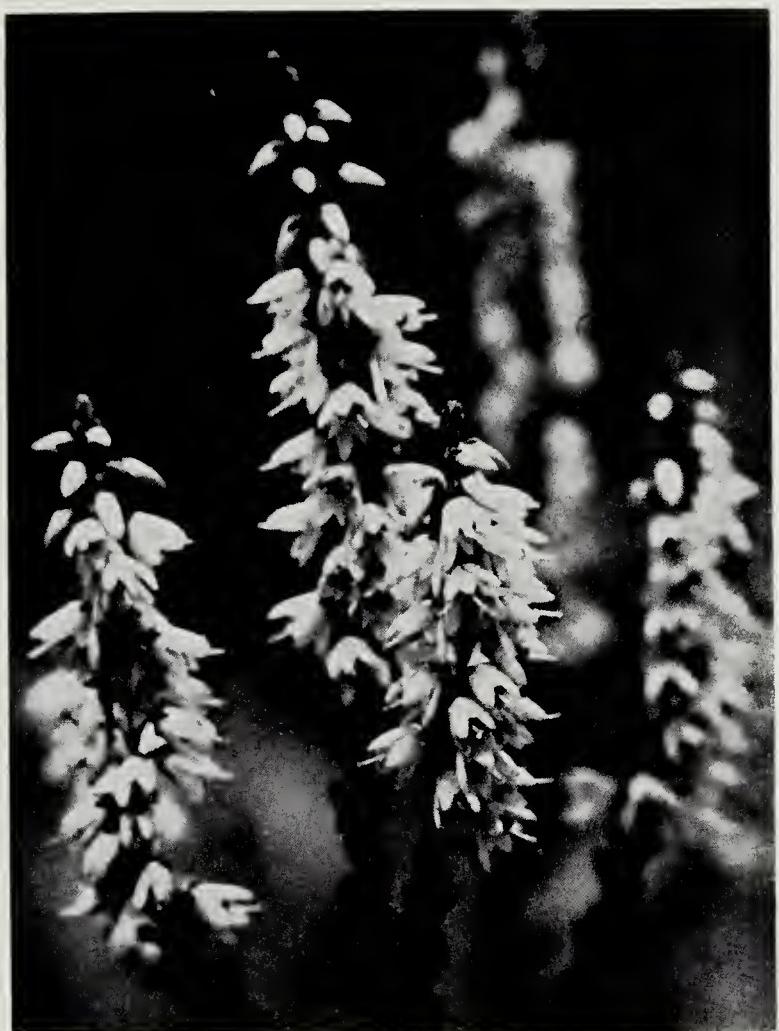


Fig. 50 *Calluna vulgaris* var. *hirsuta*

E. Mackiana but not those of *E. Tetralix* or *E. ciliaris*, and marked differences in the bundle and vestiture are among the significant distinctions noted. The study was undertaken to determine the systematic position of *E. Crawfordii* Hort., also found in Connemara, and established that the latter is "almost certainly a double-flowered form" of *E. Mackiana*.¹ Smith also concluded that *Erica* × 'Praegeri' is probably correctly regarded as a hybrid, the *E. Mackiana* influence being unmistakable and the *E. Tetralix* influence reasonably inferred.

The appearance of *Erica* × 'Stuartii' is distinctive. Its growth habit is similar to that of *E. Tetralix*, but the foliage is finer and glabrous, and the corollas are narrowly tubular, constricted at the mouth. Half of the upper epidermal cells have the transverse septum of *E. Mackiana*. Praeger (1934) considers the latter and *E. mediterranea* to be its parents, but Maxwell (1966) questions this because of the discrepancy between flowering periods. Only one clump has ever been found growing wild, in Ireland.

The Dorset heath, *E. ciliaris*, is another frequent parent of hybrid ericas, and is consider-

ed by Hansen to be closely related to *E. Tetralix*. The leaves of the former are glabrous and usually glandular, although non-glandular forms are known, and are arranged in whorls of three's. The oblique mouth of the corolla is a distinguishing character, also. (Fig. 47) The habit is straggly, erect flowering branches with terminal racemes being produced from long prostrate stems. The geographic range of *E. ciliaris* is considerably more southerly than that of *E. Tetralix*. In England, the Dorset heath is found locally only in the extreme southwest (primarily in Cornwall), then in western France, Spain, Portugal, and in northwestern Morocco, primarily in sandy marshy areas. In Philadelphia, it is damaged considerably in winter. As would be expected, its hybrids are less cold-sensitive. With comparatively large colorful corollas borne well above the foliage continuously throughout the growing season, the hybrid forms are valuable additions to heather gardens.

Erica terminalis Salisb., the Corsican heath, is native to Morocco, Corsica, Sardinia, and to southern Spain and Italy. With us, it has not yet attained the height of 8 or 9 feet ascribed to it under British conditions, but its glossy dark green foliage and erect branches make it an attractive garden design element. *Erica terminalis* does not develop short shoots, hence its erect branches have a rather rigid appearance. At the Arboretum *E. terminalis* has been killed back to near the ground in winter, but it regrows readily from the base and flowers freely in late summer. As Maxwell phrased it, the small pink flowers "burst into flower here, there and everywhere about the bush for a very long time". Apparently the Corsican heath is lime-tolerant; Hansen records it as growing on limestone mountains in Morocco, and Ingwersen (1965) writes of its growing over crumbled chalk soils.



Fig. 51 *Calluna vulgaris* 'Mrs. Ronald Gray'

¹ Cv. 'Mackiana Plena', also sold as 'Maackii Plena' and 'Mackayi Flore Plena'.

The most vigorous of the low-growing European heathers is probably *Erica vagans*, the Cornish heath. A decumbent shrub which may attain a diameter of nearly two meters, it resembles the Dorset heath in that it has no short axillary shoots, and is glabrous. (Fig. 48) The flowers, forming long cylindric racemes, are axillary and are usually borne in pairs on pedicels three or four times the length of the corolla. In Great Britain, the natural distribution seems sharply limited to the Lizard in Cornwall and Belcoo in Northern Ireland, but *E. vagans* ranges fairly far inland in France and Spain, where it appears as underbrush in pine and oak forests. It does not demand full sun or the sandy highly acid soils required by most other ericas, and at the Arboretum we find it also tolerates our winters in spite of its southerly habitat.

Three forms of *E. vagans* (cv. 'Mrs. D. F. Maxwell', cv. 'St. Keverne', and an unidentified white one) have persisted for many years and grown well in a garden on Nantucket, as has its hybrid cv. 'Williamsii'.

The form 'Mrs. D. F. Maxwell' is known to be sold by West Coast nurseries as 'E. Maxwellii'. Occasionally a non-dwarf form is sold as cv. 'Nana'.

IV. CALLUNA FORMS

One more highly important summer-flowering heather remains for consideration — *Calluna vulgaris* (L.) Hull. Although botanically it is considered one species, it has so many variants of habit, of leaf, flower, and shoot form, of color, and of vestiture, that discussion of its characteristics is material for many articles, and has already been the subject of an exhaustive monograph (Beijerinck, 1940). Suffice it to say for the uninitiated that all these forms are readily distinguished from ericas by their leaves, flowers, and fruit. The leaves of *Calluna* are sessile, appendaged, and keeled, and are arranged in four vertical rows, often so closely as to appear scale-like. This is as compared with the petioled, linear, revolute leaves of ericas arranged more openly and in whorls. (Fig. 49) The calyx of a calluna flower is at least as long as the corolla, and of similar color and texture. (Fig. 50) With ericas, the calyx is leaf-like and much shorter than the corolla. The capsules of *Calluna* are septicidal and have few seeds; those of *Erica* are loculicidal, and many-seeded.

Beijerinck determined that *Calluna vulgaris* extends over a large part of Europe and also grows in Asia and Africa. It has been found from the extreme northern part of Norway ($71^{\circ} 5'$ latitude) to Morocco, and from Iceland to the Ural mountains. The distribution of

naturalized locations in North America has already been mentioned (Emerson, 1967).

As would be expected, there is variation in the way different forms of *Calluna vulgaris* behave. Flowering may commence from mid-June to mid-September, and continue for two weeks to six months, either continuously or intermittently. A few forms seem to be particularly susceptible to pathogens; the cultivars 'Sister Anne', 'Pygmaea', 'Mrs. Pat', and 'Elegantissima' are in this category. And inevitably there is some confusion about cultivar names. We have noted that forms listed by certain nurseries as 'Multiplex' and 'Plena Multiplex' seem identical to 'Flore Pleno' when grown side by side. 'Aurea' and 'Cuprea' have been badly confused by many nurseries, and 'Searlei Aurea' or 'Hammondii Aurea' (or is the latter properly 'Hammondii Aureafolia') are frequently labeled 'Aurea' or 'Aureafolia'. (The two-year-old branches of true 'Aurea' are stiffer than those of 'Cuprea', the foliage coloring of the latter is darker except in summer, and its short-shoot leaves are smaller.) Plants which are evidently 'Mair's Var.' or 'Pyramidalis' have been sold as 'Searlei'; those distributed by one nursery as 'Tomentosa' have lavender flowers instead of white. 'C. W. Nix' from another source has double strong red-purple (Nickerson 2.5 RP 5/10) flowers instead of resembling 'Alportii' as the introducer indicates it should. Plants from the latter have now been received at the Arboretum, but have not yet flowered. Some specimens of 'Mayfair' grow upright, but others are always decumbent. British gardeners consider the name 'Foxii Floribunda' inappropriate, but it describes well the flowering of the form we have with that name. There is some question about the identity of 'Nana Compacta'. There are also small labeling errors, such as "Mrs." H. E. Beale and "Mrs." J. H. Hamilton, whereas those forms were both named for men. Similarly, although Dr. Gray's wife is Mrs. R. H. Gray, the cultivar named for her was introduced as 'Mrs. Ronald Gray'. (Fig. 51)

Beijerinck studied all the *Calluna* forms he could find and proposed a drastic revision of nomenclature, but it has not been adopted. In Great Britain, beside the trials at Wisley a sub-committee of The Heather Society is working on the problems of heather variety names and has already accomplished a good deal by census. McClintock (1965, 1966a, 1966b, 1967) has been especially concerned and his findings are published from time to time.

A great number of forms have already been introduced commercially. Although many were not truly justified, more new forms are being

offered and several of them are more interesting than older cultivars. In the Morris Arboretum Heath Garden there are many *Calluna vulgaris* cultivars and *Erica* taxa which had not been established long enough to include in Table 1, and still more forms are waiting to be planted in the garden next spring.

In spite of the notorious Philadelphia climate, with its hot humid summers and its sharply fluctuating temperatures in winters with or without snow cover, callunas and ericas have grown remarkably well at the Morris Arboretum. Plantsmen and gardeners are finding that a wide variety of heathers, once thought difficult, can be grown satisfactorily in eastern North America and provide great pleasure throughout the entire year.

ACKNOWLEDGMENTS

The generous support of Dr. J. M. Fogg Jr. and the cooperation of the Morris Arboretum staff have made working with heathers a joy. I wish to acknowledge my grateful appreciation to them, and to Dr. T. R. Dudley of the U. S. National Arboretum; to Harold W. Copeland of Chatham, Mass.; to Roy J. Kersey of Devon, Pa.; and to the late Esther Deutsch of Huntington, N. Y. All have freely shared their knowledge and plants; their enthusiasm has been stimulating and their help invaluable as we learned more about heathers in our part of the world.

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New Associates

The Arboretum is happy to welcome the following new Associates who have been enrolled since June, 1967:

- Mr. Dick Bolton
 Mr. H. C. Cheetham
 Mr. Herbert P. Hanisch
 Mr. Harry L. Irving, Jr.
 Mr. William M. Long
 Mrs. Harold N. Nash
 Mr. and Mrs. John S. Peake

- Mrs. Lewis T. Riddell
 Mr. Walter A. Siri
 Mr. John E. Strong
 Mr. James D. Ulrich
 Mr. Louis W. Van Meter
 Mrs. Arthur E. Weil

Cytology and Sterility in *Elliottia racemosa*

FRANK S. SANTAMOUR JR.¹

ABSTRACT

Cytological studies showed *Elliottia racemosa* Muhl. to be a diploid with $n=11$ chromosomes and normal meiosis. However, progressive pollen abortion resulted in only 5-6% stainable pollen at anthesis. Controlled self-and cross-pollinations produced no fruit or seed. An hypothesis is advanced to explain the development of genic sterility in *Elliottia* and the reproductive capacity of the plant is discussed in relation to its maintenance in the wild state.

Elliottia racemosa Muhl. ex Ell. (often called Georgia-plume) is one of the rarest of our native woody plants, both in the wild and in cultivation. The genus *Elliottia*, a monotypic genus of the Ericaceae, commemorates the American botanist Stephen Elliott (1771-1830). Although it is possible that the plant was first seen by William Bartram (Mellinger, 1967), it was Elliott who brought it to the attention of the botanical world when he discovered it during the field work for his "Sketch of the Botany of South Carolina and Georgia." He sent specimens to Dr. Muhlenberg in Lancaster, Pennsylvania, who suggested its generic name (Small, 1901). The original locality of collection was near Waynesboro, Burke County, Georgia and subsequent collections were made in several other counties of Georgia as well as one station in South Carolina, across the Savannah River from Augusta, Georgia. However, *Elliottia* has been confirmed in only a few of the stations determined before 1930 and Wood (1961) stated that it now exists only in isolated colonies in Columbia, Screven, and Coffee Counties in Georgia. Mellinger (1967) has recently given additional information on its natural occurrence.

Elliottia is a shrub or small tree up to 20 feet in height and produces numerous racemes or panicles of fragrant white flowers (40-80 per raceme) in July (Fig. 52). The attractiveness and rarity of the plant commanded the interest of many early botanists and horticulturists but their efforts to bring *Elliottia* into cultivation were not eminently successful. Rehder (1940) gave 1813 as the date of cultivation, based on Muhlenberg's statement that he had observed the plant in a private garden. The next successful attempt at cultivation occurred in 1875 when a Mr. Berckman, in company with Asa Gray, collected a few plants near Augusta, Georgia, and established them in Mr. Berckman's nursery in that city (Sargent, 1902). In 1902, Mr. Berckman sent two plants to Kew Gardens and one of

them flowered in 1911 (Osborne, 1912). According to Trudell (1926) there had been only four previous findings of *Elliottia* in the wild, and only the above two instances of successful cultivation. Fortunately, since that time there have been other successes and the plant has become established at several botanical institutions. The Morris Arboretum received two plants from the Biltmore Estates, Asheville, North Carolina, in 1958 and although one plant succumbed to borer attack the other is still flourishing in the Heath Garden.

EVIDENCES OF STERILITY

The early observers noted that, in very few instances, were seedlings found in the same locality with flowering plants. Indeed the fruit of the plant was unknown until Harper (1903) discovered single empty fruit capsule. It was not until 1935 (Wherry, 1935) that the first seed was described, and even then the embryos were not fully developed. The lack or scarcity of seed production in nature and in cultivation led to the impression that *Elliottia* was on the road to extinction. Knight (1938) has stated however, that there are several stations where the species is propagating itself by seed . . . "so that it is definitely not sterile to its own pollen."

If *Elliottia* is, ". . . definitely not sterile. . ." it is certainly not abundantly fertile. Knight (1938) also gave some data on seed production in the wild in 1936. A single plant produced only 8 capsules and no filled seed from 1000 flowers. Another group of plants produced only 28 capsules from ca. 16,000 flowers and no germination was reported from the several institutions to which the seed was sent. In this area, plants grown at the Henry Foundation, Gladwyne, Pennsylvania and by Mr. Henry J. Hohman, Kingsville, Maryland have produced seed at various times in recent years but no germination has been reported.

Osborne (1912) reported on the unsuccessful attempt at artificial self-pollination of the first-

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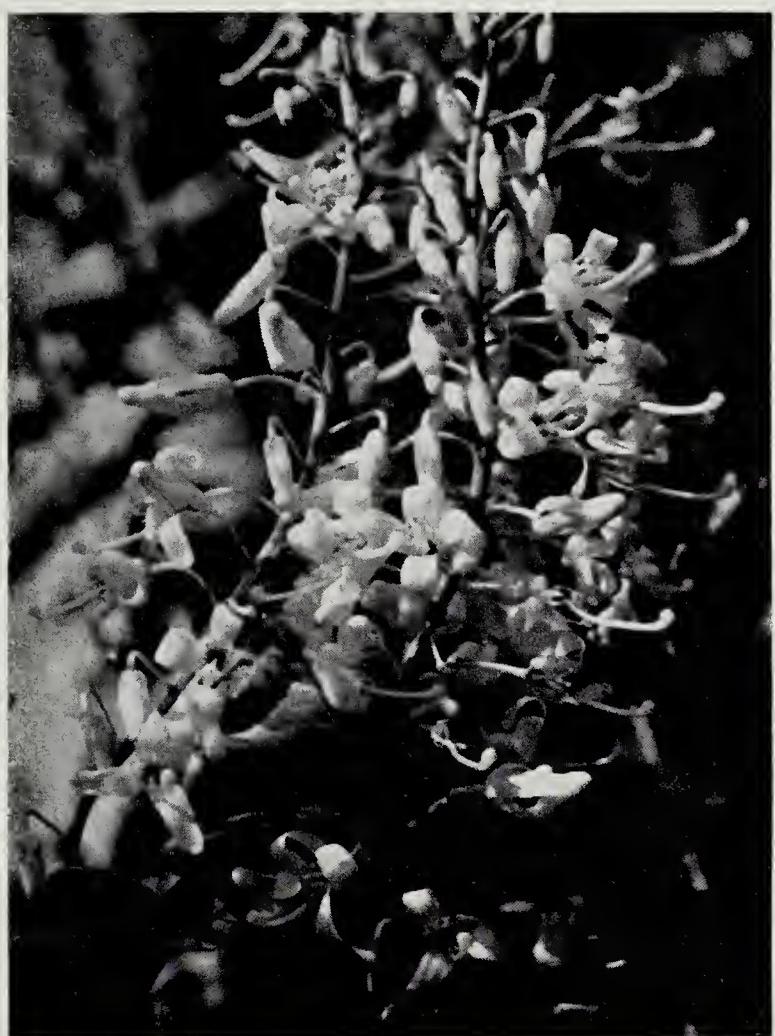


Fig. 52 Inflorescence of *Elliottia racemosa*

flowering *Elliottia* at Kew. Both early and late pollinations were tried but no fruit was produced. Wherry (1935) mentioned that. . . ". . . attempts to cross-pollinate different colonies in the field and in cultivation have failed." In 1966 we pollinated about 50 flowers of the Morris Arboretum plant with pollen from the Hohman specimen and also attempted 25 self-pollinations. No fruit matured to either artificial or natural pollination. The original Hohman plant was received as a seedling (?) from the U. S. Plant Introduction Station, Glenn Dale, Maryland in the late 1920's or early 1930's (H. J. Hohman, personal communications), so that it is unlikely that both plants belong to the same clone.

The above observations and data indicate that *Elliottia* is highly self-and cross-sterile, and that the production of viable seed occurs only in rare instances that may depend on a combination of genetic and environmental factors. How, then, has *Elliottia* maintained itself, albeit in small numbers, through the centuries? Early reports stated that the species was able to reproduce by root suckers, and Trudell (1926) reported a colony of 24 plants whose roots appeared to be

interconnected. Knight (1938), however, found no evidence of propagation by root suckers. The species may be vegetatively propagated, although with some difficulty, by root cuttings and Mr. Henry J. Hohman has propagated his plant from root suckers produced on severed roots left *in situ*.

CYTOTOLOGICAL STUDIES

The apparent high degree of sterility in *Elliottia* prompted a study to determine if the sterility had a cytological basis. No previous cytological work has been reported on *Elliottia*, although Wood (1961) mentioned that an unsuccessful attempt to study meiosis had been made.

Likewise, our attempts to study the chromosomes in 1966 were not successful. However, some meaningful observations were made on the pollen. The pollen of *Elliottia*, like all other Ericaceae, is shed in tetrads rather than as individual pollen grains. The degree of pollen fertility, based on stainability with aceto-carmine, was determined for both the Hohman and Morris specimens. The data for the two plants were quite comparable. Only 19% and 20% of the tetrads contained one or two stainable cells. On the basis of individual cells, pollen stainability was 5.5% and 5.9%. Such low pollen fertility is not generally found in a good species.

In 1967, racemes were collected and fixed in Carnoy's fluid at various times from mid-June to mid-July. Anthers were dissected out of the flowers and subjected to standard aceto-carmine squash techniques. Even with an abundance of material in varying stages of external development the meiotic stages were difficult to find. After examining some 50 flowers, two were found that provided all the stages of meiosis up to teleophase II. The haploid chromosome number was determined to be $n = 11$ and there were no marked abnormalities in either division. Thus it would appear that *Elliottia* is a diploid species and that the observed high pollen sterility is not the result of apparent hybridity or polyploidy.

Pollen abortion was noted to begin shortly after the development of the pollen-grain walls and continued until anthesis. Study of a succession of buds from tip to base of a raceme showed a progressive increase in abortion. Some cells appeared empty and shriveled at a very early stage while others aborted at more advanced stages of development. In the latter instance, abortion was characterized by the formation of oil droplets in the pollen grain. In 1967, naturally-shed pollen of the Morris specimen was only 5.6% stainable, with 20.7% of the tetrads containing one or two fertile grains.

FLORAL DEVELOPMENT

Because of the general lack of fruit and seed production to both natural and controlled pollination, it could not be determined whether *Elliottia* is normally self- or cross-fertilized. The following observations on floral development may provide a basis for future work on this subject.

As the flower developed the petals were tightly enclosed around the sexual parts. Separation of the petals occurred first in the region of the anthers, 2 to 4 mm. from the base of flower. However, the anthers had dehisced and pollen was shed some time before the anthers were visible through the slits afforded by the separation of the petals. Therefore, the species appears to be protandrous. It was found that at the time pollen was shed, the stamens were about 4 mm. long and the tips of the anthers were just below the stigma. Following anther dehiscence, the style continued to elongate, even though enclosed by the petals, and was about 10 mm. long when the tips of the petals finally separated. Little or no stylar elongation (less than 1 mm.) occurred after petal separation. Curvature of the style to present the stigma in an upright position began when the style was 7-8 mm. long and still enclosed by the petals. Petals and anthers were shed within a few days after emergence of the stigma.

At all times from anther dehiscence until total petal separation and release of the stigma, the stigma was covered with pollen produced in the same flower. Even after all the other flower parts had dropped, some of this pollen (with viscid strands) could be found on the stigmatic surface. On some occasions we used the stigmas of flowers that opened in the laboratory as pollinating "brushes".

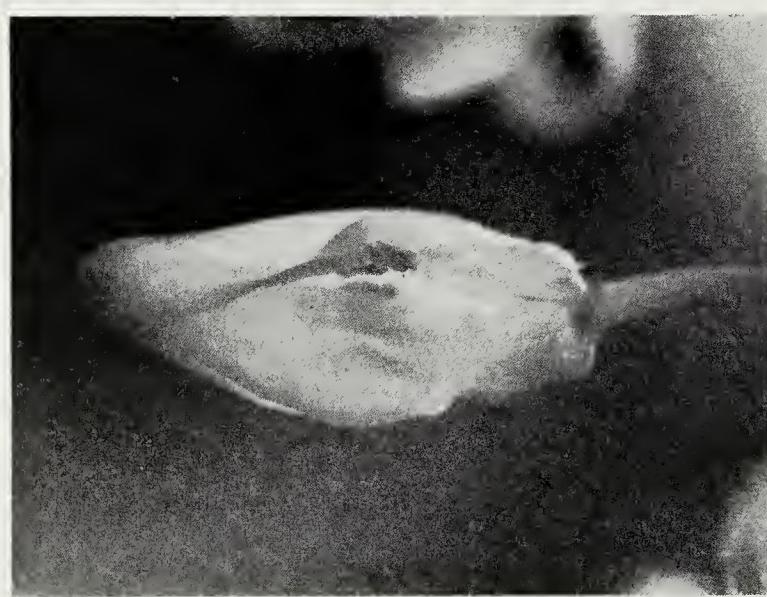


Fig. 53 Opening flower of *Elliottia racemosa*, showing separation of petals at middle of corolla

A great many insects were attracted to the flowers, and several kinds of bees (species not determined) were seen to visit the flowers from the time of initial petal separation until the petals were shed. It was not determined whether these insects actually carried pollen from one flower to another, but the logical inference of such insect activity is that these bees may be effective in cross-pollination.

Thus, no conclusions can be made as to the normal course of fertilization. Both self- and cross-pollination probably occur in all flowers during the period of maximum stigmatic receptivity. More intensive studies, perhaps on plants in the wild, will be necessary to settle this question.

DISCUSSION

The scarcity of viable seed production in *Elliottia* can be traced, in part, to a high degree of pollen abortion. Since meiosis appears perfectly normal, it is likely that the pollen abortion is caused by factors other than those normally associated with hybridity or polyploidy; that is, the cause is genic rather than chromosomal. If there are similar disturbances in the development of the egg cell and/or genetic incompatibilities within or among individuals, the production of normal, viable seed would be a rare event indeed.

Although wisdom may frequently dictate otherwise, it is incumbent upon an investigator to at least offer an hypothesis for observed plant behavior, even though the evidence and data are not as complete as he would like. Therefore, the following paragraphs are given as a possible explanation of the development of sterility in *Elliottia*.

The Hardy-Weinberg Law essentially states that the genic or gametic constitution of a population at equilibrium remains constant from one generation to another. This equilibrium may be upset by mutation, migration, or selection and may be approximated only under conditions of random mating in interbreeding, diploid populations of infinite size. *Elliottia*, during recent time at least, has occurred in small, isolated colonies that usually contain less than 50-100 plants. Under such conditions, even with obligate cross-fertilization, the mating system becomes non-random and a certain amount of inbreeding occurs in each generation. Such mild inbreeding (parent × progeny or half-sib mating) will, over geologically long periods of time, result in a degree of uniformity similar to that produced by selfing. One of the major effects of this type of inbreeding is the fixation of non-adaptive or deleterious recessive genes. In small, isolated



Fig. 54 Open flower of *Elliottia racemosa*

populations random changes in the population level, caused by fire, disease, or other agencies, increase the possibility of fixation of undesirable genes. If a species is capable of vegetative reproduction by root suckers, a drastic reduction in numbers may result in populations composed of only one or a few clones.

It is postulated the high degree of pollen abortion observed in *Elliottia* is the result of an accumulation of recessive lethal and sub-lethal mutations at various loci. In this connection, it is impossible to discount small chromosomal deletions or duplications which may have lethal effects but are not sufficiently large to cause meiotic irregularities. These recessive lethal genes generally are of little consequence in the diploid condition, where the regulation of a necessary metabolic function is under control of the normal allele. However, in the haploid condition, as in pollen grains, the action of a recessive lethal may be manifest in the absence of the normal allele. A single lethal gene then could theoretically result in 50% pollen abortion and would be effectively removed from the breeding population, although it would remain in the original plant. However, there are undoubtedly many mutant genes which may be termed sub-lethal, in that they may modify a specific reaction so as to bring about abortion only under certain environmental conditions or in concert with certain other gene combinations.

Thus these sub-lethals could be transmitted from generation to generation and become fixed in a population. Various sub-lethals could modify different processes or different stages of the same process, so that abortion of pollen might occur at varying stages of development (as observed in *Elliottia*).

Regardless of its doubtful and/or varied capacities to reproduce itself vegetatively or sexually, it is obvious that *Elliottia* is in danger of disappearing from the wild. The scarcity of reproduction, the vagaries of the environment, and the encroachment of civilization argue for the eventual extinction of the species unless intentionally conserved by man's efforts. A major step in this direction has been achieved with the establishment of the 72-acre Charles Cotton Harrold Nature Preserve, which was deeded to the Nature Conservancy in 1964 (Mellinger, 1967).

ACKNOWLEDGMENTS

Mrs. Barbara Emerson was instrumental in the initiation of this study and collected the material for cross-pollination. Dr. John M. Fogg, Jr. provided encouragement and advice while Dr. Patricia Allison and Mrs. Emerson furnished the photographs.

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Self-Unfruitfulness of some Magnolias

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While most species of cultivated magnolias are planted because of their flowering qualities, and some also for their ornamental evergreen or deciduous leaves, the brightly colored seeds and decorative fruits give considerable additional landscape interest to trees which bear them in appreciable amounts. Arrangers also like the "cones". Home and public garden landscapers who may never sow a seed will, therefore, be often nearly as interested as the nursery-men and plant breeders in providing conditions to increase the production of seeds on some of their magnolias. Evidence is accumulating that the provision of different clones for natural cross-pollination often will greatly increase fruitfulness in several species and varieties.

Certain hybrid trees may never produce many seeds even under the most favorable conditions. One such category includes most F₁ hybrids between parents with differing chromosome numbers, which often have meiotic irregularities and consequently low fertility (or no fertility) in both pollen and egg cells. The best-known of several examples are the original *M. × Soulangiana* cultivars, pentaploid offspring of crosses between the hexaploid *M. denudata* (2n=114) and the tetraploid *M. liliiflora* (2n=76). The usual F₁ clones of *M. × Soulangiana*, though weakly if at all fertile, have in some cases given recombinations and presumed backcrosses like var. *Lennei* and its probable or known seedlings (including 'Rustica', 'Grace McDade' and 'Lombardy Rose') often with very good fertility, mainly at the hexaploid level, so far as cytological examinations have shown. These hybrid-derived hexaploids appear to be self-fertile, and also should be cross-fertile with other hexaploids of the section Yulani, both the natural species and such F₁ hexaploid hybrids as *M. × Veitchii*.

Similarly, in the other subgenus, Oliver M. Freeman's series of hybrids (1) at the U. S. National Arboretum, between *M. virginiana* (2n=38) and *M. grandiflora* (2n=114) includes some trees in which the present breeder there, W. F. Kosar, and I can observe no ap-

¹ In this discussion, I have drawn freely on the observations of other breeders and arboretum horticulturists, some of whom were shown a preliminary draft of this paper, and generously shared their experiences.

parent shedding of pollen, and none with more than infrequent, partially filled mature cones. However, the one cultivar of this group so far named ('Freeman') does have viable pollen in some of its flowers, and I have used it to secure several backcross hybrids with both its parent species.² (Fertility appears to be lacking in two presumably triploid or aneuploid backcrosses of *M. virginiana* × 'Freeman' which first flowered in 1967.)

Even hybrids between diploids in different sections of the genus can have inherently low fertility. Thus George H. Johnstone ("Asiatic Magnolias in Cultivation", p. 33) cites only one instance in Britain where the hybrid *M. × Watsonii* (*M. Sieboldii* × *M. obovata*) regularly ripens seeds. Joseph A. Witt reports that it has never produced seed at the University of Washington Arboretum, but it has been a shy bloomer in its shaded location in Seattle. Santamour has demonstrated chromosomal irregularities in microsporogenesis of the original clone of *M. × Thompsoniana*, with consequently very low percentage of normal pollen grains. This, together with probably parallel defective egg-cell development, would accent for the very rare production of seeds on this intersectional hybrid between *M. virginiana* and *M. tripetala*. In 1967, I had no fruit development from ten outcrossed flowers on two new F₁ clones of this parent-age, and their pollen failed to set seed on either *M. virginiana* or *M. virginiana* var. *australis*. Such sterility may prove rather general in other *virginiana* × diploid intersectional hybrids. Still awaiting their first flowering are my recent hybrids of *M. virginiana* × *M. macrophylla*, and W. F. Kosar's (at the U. S. National Arboretum) between *M. virginiana* and *M. guatemalensis*. Mr. Kosar (personal communication) now has flowered his series of older hybrids between *M.*

² The evergreen Magnolia cultivars 'Madison' and 'Charles Dickens', both found as unpreserved seedlings in the Tennessee Valley, appear to have been derived from natural hybrids involving *M. grandiflora* and other species, probably American diploids. Both are quite fertile to self or open pollination. Unlike 'Freeman', neither is probably an F₁. I should guess *M. virginiana* var. *australis* to be the other original parent of the small-leaved 'Madison', and *M. macrophylla* (or *M. Ashei*) as one ancestor of 'Charles Dickens'.



Fig. 55 *M. Ashei*. Flower and leaf from tree of Florida source.

obovata and *M. virginiana* (deciduous) but has not obtained seed production with any of them in the seven years since the first flowers developed in 1960. He adds, "I even tried a few controlled pollinations, backcrossing to *M. virginiana* with no success. I suspect the problem is similar to that reported by Santamour on *M. × Thompsoniana*."

With several pure species, or hybrids between closely related species, isolated trees (and some not so isolated) can still be poor seed producers to self- or open-pollination. This is indicated by D. Todd Gresham who also suggests other possible factors in recent notes from Santa Cruz, California. He writes: "Here, possibly due, in part, to the air-moisture from my nearness to the Pacific, selfed seed is a rarity. When selfed seed does set the pods are skimpy, not to be compared with a big fat artificially set one. *M. Soulangeana* does not set selfed seed, but a cross of similar parentage (my 2 × 60) delights me by loading itself consistently with big fat selfed cones, even on small seedling trees. It must be considered vigorously self-fertile. I had not previously considered the possibility that it could be a hexaploid."

"With regard to self-infertility of *M. liliflora* and *M. denudata*: for some twenty years I have observed three plants of *M. liliflora* at least 60 years old. During this period I have never seen a self-fertile seed pod. Still crossed with a variety of pollens they set well-filled seed cones. The oldest *M. denudata* of my acquaintance, and from which most Californian *M. denudata* are descended, has never set a selfed cone. My observations certainly coincide with your theory of

their self-infertility." Mr. Witt, in a December 1, 1966 letter, wrote of similar observations, saying, "This year . . . we had a number of cones on *M. denudata* for the first time that I can remember." Rare seed production is also reported by David Paterson for the large *M. denudata* trees in Longwood Gardens, Kennett Square, Pennsylvania. K. Sawada in 1950 (7) reported greater seed production on *denudata* than on any other Oriental magnolia, but he had a number of other hexaploids, and two different *denudata* clones that could have interpollinated. Mr. Sawada's son told me in 1967 that they get few if any seeds on *denudata* by open pollination. His father may have meant that *denudata* was very fertile to controlled outcrossing. In this, several breeders will agree.

In Illinois I obtained in 1965 successful hybrid seed production from hand-pollinations, making two crosses — *M. liliflora* × *M. denudata* and *M. denudata* × *M. Sprengeri* var. *diva*, on two trees in Decatur, whose owner had never seen them produce any seeds during the previous 20 years. (These are reciprocals respectively, of the old cross by Soulange-Bodin, and a recent one made by Kosar.) In Illinois, also, another tree of *M. denudata* and a minor part of the *M. liliflora* plants in Champaign-Urbana, Carbondale and Mt. Pulaski have occasionally been observed to set seeds, but in all cases they were near *M. × Soulangeana* or one of its offspring, and often near trees of *M. acuminata* whose flowering frequently overlaps that of *M. liliflora*. A frequent seed producer, though never a heavy one to natural pollination, is the small tree in Champaign (owned by the O'Neill sisters) that agrees with the color plate of *M. liliflora* in Johnstone's "Asiatic Magnolias in Cultivation."

(3) It stands very near a big *Soulangeana* tree, within a block or two of our usual *liliflora* form in Illinois (the clone possibly miscalled var.



Fig. 56 *M. liliflora*. Total 1965 fruit crop from one tree. The 17 fruits on the right are from hand-pollination by *M. denudata*.

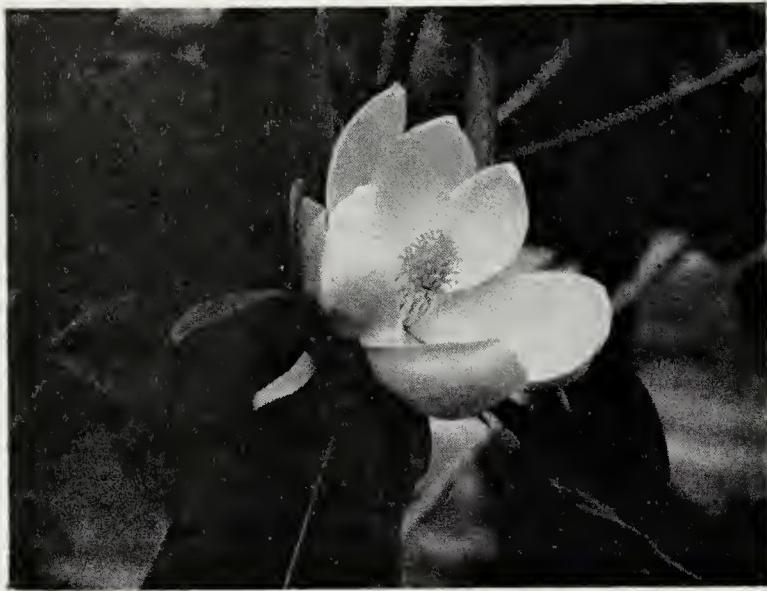


Fig. 57 *M. obovata* × *M. virginiana* var. *virginiana*.
Courtesy U. S. National Arboretum.

nigra), and within two blocks of two big *acuminata* trees. I have not yet seen seeds on any plant of either *M. liliflora* or *M. denudata* where cross-pollination could have been entirely ruled out.

Mr. Gresham notes that at least one American tree seedsman offers both *M. denudata* and *M. liliflora* seeds by the pound. Perhaps these seeds are produced in Japan, where, the trees having been long under cultivation, both species may have a fair number of clones in propagation. (The usual poor viability of imported magnolia seeds is said to apply to both Japanese and Indian sources.) Johnstone (3) thought that the limited natural seed production of *M. denudata* "offers no encouragement to the would-be hybridist," but this conclusion ignored the good cross-fertility now demonstrated in old and recent hand-pollinations using *denudata* as either seed or pollen-parent.

Skimpy seed production, or often no seeds at all, is the usual report for isolated trees of *M. acuminata*, or even groups of probably related trees (such as the old giants in Longwood Gardens), but there are some exceptional isolated specimens of this species which regularly set heavy seed crops. Two which I have previously reported (4) have been started on the way to commercial nursery production. The variety *cordata* (sometimes regarded as a distinct species) also seldom sets seeds alone, but Freeman (2) demonstrated its reciprocal cross-fertility with typical *acuminata*. At the Arnold Arboretum, where *cordata* and various sources of typical *acuminata* are grown near each other, both varieties in 1966 were more fruitful than is usually the case where I have seen them growing alone.

In *M. virginiana* both the typical glabrous (to glabrescent) and deciduous var. *virginiana*, and its widely cultivated pubescent but deciduous form (which I have found to be native at least around Wilmington, North Carolina) appear consistently self-fertile. But the more often persistent-leaved *M. v.* var. *australis* Sarg., as indicated by specimens planted outside its mainly southern coastal plain habitat, may have as high an incidence of self-infertility as *M. acuminata*. However, there appears to be an occasionally self-fertile minority. Witt indicates the same varietal differences at the University of Washington Arboretum, where "we have never had spontaneous fruit on var. *australis*."

Oliver M. Freeman, who planted an *australis* tree from a nearby Polk County outpost on his former summer home grounds near Tryon, North Carolina tells me that it flowers well but sets no seeds, though in 1966 we observed fruits on some trees in the stand it came from, near Columbus in that county. The pollen of Freeman's *australis* tree is apparently normal, and I used it success-



Fig. 58 *M. acuminata* near Philo, Illinois.



Fig. 59 Fruits from an isolated tree of *M. acuminata* near Princeton, Illinois.

fully in 1966 in one of a series of inter-varietal hybridizations I have made between var. *virginiana* and var. *australis*. Another transplanted var. *australis* clone, moved from the vicinity of Hammond, Louisiana to the home of J. F. Pieratt in Houston, Texas, also flowers well but had set no fruit before 1967, even with *M. grandiflora* overlapping its flowering season in the same yard. In 1967, it has set fruits to *australis* pollen of different clones. Still another *australis* tree, bought from a North Carolina nursery and set as the lone sweet bay known in the town of Sesser, Illinois, does produce seeds there, but apparently the major part of them in some years are set by natural cross-pollination with nearby *M. grandiflora*. In 1964, when it produced many seeds, some fifty or sixty of them were planted by Joseph Hickman in his nursery at Benton, Illinois. He germinated about 25 natural hybrids, with the general appearance of *M. grandiflora*, and only one glaucous leaved pure *M. v.* var. *australis*. However, 1966 crop seeds from the Sesser tree gave me only *australis*. With the one seedling *M. v.* var. *australis* so far flowering freely at Urbana, Illinois, I have made crosses using *M. grandiflora* pollen, and obtained several true hybrids in addition to apparent apomicts. It also is quite fruitful when outcrossed to either var. *australis* or var. *virginiana* clones.

Two other isolated var. *australis* clones are noted as scant seed producers at their first planting sites. As male parents both have been fertile pollen sources for inter-varietal crosses, and both have given hybrids (not yet flowered). One tree, in Mt. Pulaski, Illinois, in some years sets no seeds, though there are numerous var. *virginiana* trees (all fertile) growing near it in that town. The other is the newly named cultivar 'Henry Hicks', (5). This hardy, persistent-leaved tree

whose original seed provenance is unknown, was long grown with one other sweet bay plant of typical var. *virginiana* near it, in the arboretum of the Arthur Hoyt Scott Horticultural Foundation at Swarthmore College, Swarthmore, Pennsylvania. The typical clone is fruitful, but the evergreen one matures only a few cones with few seeds. David G. Leach, who grew rooted cuttings of 'Henry Hicks' at Brookville, Pennsylvania (where it is "as evergreen as any *Rhododendron*") found it set no seed with pollen of *M. grandiflora* and some more distant species. But a young 'Henry Hicks' graft at Urbana matured seeds with pollen of two different *australis* clones. (Its pollen is cross-fertile with both *australis* and *virginiana* clones.)

Among the other American species, many *Magnolia grandiflora*, *M. macrophylla*, and *M. tripetala* trees in isolated plantings all show good seed production, which indicates a high level of self-fertility. I have not observed enough out-planted trees of *M. Fraseri* to establish its norm, but some rather isolated trees seem self-fertile, and Witt lists it among species often setting good crops at Seattle. For the seldom-cultivated *M. pyramidata* I lack data except for one cultivated tree fertile at Mobile, Alabama. A lone tree of *M. Ashei* that sets many seeds in Rochester, New York, is thought to be fertile to its own pollen, but it possibly could receive some cross-pollination from trees of the closely related *M. macrophylla*.

M. Sprengeri var. *diva* and most of the other cultivated Asian magnolia species except those previously mentioned show apparent self-fertility. Witt's fruitful list at Seattle includes *M. cylindrica*, *M. obovata*, *M. Sargentiana* var. *robusta*, *M. Sieboldii*, *M. sinensis* and *M. Wilsonii*, plus "*M. stellata* (especially second generation plants from Arnold Arboretum seed)." Several *stellata* clones are fruitful at the Arnold and in Illinois. *M. officinalis* var. *biloba* gives true-to-variety seedlings from a seed-grown tree in Livonia, Michigan.



Fig. 60 *M. officinalis* var. *biloba*. Seedling at Urbana, Illinois.



Fig. 61 *M. virginiana* var. *australis*. Fruit set by cross pollination.

M. salicifolia may be an exception, but probably needs more study in isolation, or controlled pollinations (self- and out-) to really settle its status. Both British and American growers have noted the variability of *M. salicifolia* seedlings, some of which lack the typical narrow leaves and also the pronounced anise odor in their foliage which is the source of the "Anise Magnolia" common name. Johnstone mentions variations in growth habit. We do know that it sometimes produced natural hybrids with the *M. Kobus* alliance, witness the \times *Proctoriana* and Slavin cultivars. With seeds collected at the Arnold Arboretum, on a tree near numerous other Buergeria section diploids, I think I may have grown as many or more hybrids than pure *M. salicifolia* seedlings, judging from their first year's growth. I'll let Mr. Witt, who has observed more of the species, write the next paragraph.

"Our experience with *M. salicifolia* and *M. Kobus* would indicate that they fruit about the same. Our *M. Kobus* 'Wada's Memory' has on occasion produced a bumper crop of seed, but then so has our 'Else Frye' which seems to be pure *salicifolia*. I suppose we have a dozen *M. salicifolia* in the arboretum and I have noticed a very considerable amount of variation in pubescence of the leaf buds. There is also some difference in the width of the leaves and in the flower shape. The latter two I feel could well be intra-specific variation. However that may be, we do not get much seed set on any of these."

As previously noted, the hybrid *M. × Watsonii* (*M. Sieboldii* \times *M. obovata*) apparently rarely sets seeds. Johnstone (l. c., p. 114) notes that the one *M. × Watsonii* which frequently ripens seed in England is in the same garden where *M. Sieboldii* (one of its parents) frequently produced self-sown seedlings, and we

may infer that there could be some natural cross-pollination of the hybrid by the species. Another possibility is that the *M. × Watsonii* has mutated to a more fertile form.

For natural seed production, then, the magnolia planter, assuming that he is in a favorable climate and that his local insects will transfer pollen from older flowers to newly-opened flowers or mature buds, can:

- (1) Plant only a tree or trees of species or balanced hybrids known to be reliable seed producers to their own pollen.
- (2) Plant selected exceptionally self-fruitful clones, if using *M. acuminata* and some other species or hybrids. (Pentaploids, triploids, and inter-sectional F₁ hybrids = seldom if ever will qualify.)
- (3) Plant, or get one of his neighbors to plant, within insect-flight distance, a different but inter-fertile clone to supply pollen for his self-unfruitful tree. Apparently both trees must belong to the same sub genus, and preferably to the same section. Then if they both flower at the same season,

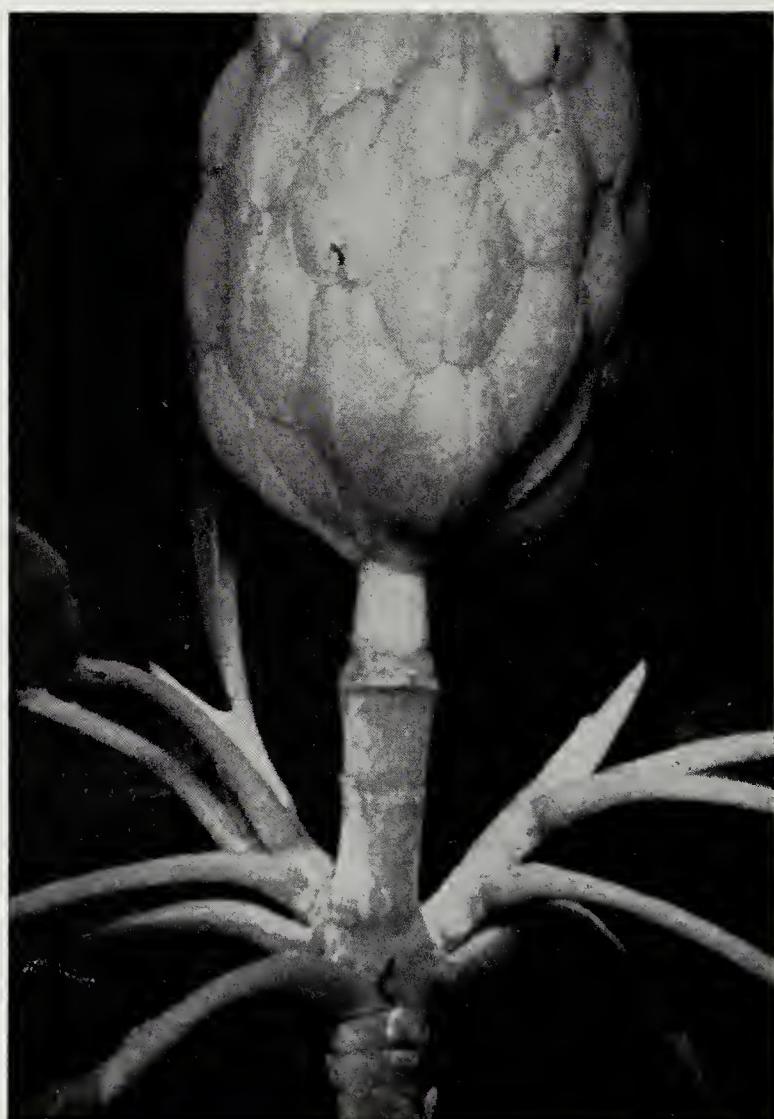


Fig. 62 *M. virginiana* var. *australis*. Texas source with full fruit set by *M. virginiana* pollen.

and if the insects do their part in transferring pollen, both trees can load up with fruits and seeds.

Not too many growers, unless they hand-pollinate, will encounter the problem mentioned by Mr. Gresham in another note: "I love to see the trees loaded with fruit, so much so that on several occasions I have practically killed them by over-pollinating. Formation of seed must be terrifically depleting."

I would agree with Joseph A. Witt, who writes: "We think that there are a number of other factors as well as self-incompatibility especially in our Seattle climate. This would be indicated, we feel, by the variation in the number of fruits set on a given tree in various years. This year, for instance, we had a number of cones on *M. denudata* for the first time that I can remember. Yet we had practically nothing on our *Kobus*. We also know nothing about the insects which accomplish magnolia pollination. My own observations have been that there is a small pollen thrip living in the bottom of the magnolia flowers and these must accomplish what self-

pollination occurs. Surely we must have more work on climatic factors and insect vectors before we can know too much more about the problem of fertility in magnolias.

It is hoped that this article will stimulate other readers to contribute their own observations, particularly on Magnolias not very commonly cultivated. If you don't publish elsewhere, let Dr. John M. Fogg, Jr., have your notes for the American Magnolia Society Newsletter.

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Arboretum Activities

(Continued from Page 50)

THE STAFF

Mr. John Dourley, our talented and devoted Superintendent for 11 years, has accepted a similar position as of 1 September at the Rancho Santa Ana Botanical Gardens in Claremont, California. Everyone in the University is certainly grateful for his years of dedicated service and we wish him well in his most significant new post.

With the departure of Mr. Dourley, Mr. Domenic De Marco, Gardener-Foreman and Mr. John Tonkin, Superintendent, Emeritus, together with the associated staff, are rendering invaluable service during an inescapably difficult period of transition.

For the thirteenth consecutive year Dr. Fogg offered a six weeks graduate course on "The Identification of Woody Plants" under the auspices of the Summer School of the University. As in previous years the class was composed of high school teachers of biology, who were en-

rolled in the National Science Foundation Summer Institute, and graduate students in the University's Division of Landscape Architecture. The class was conducted at the Arboretum where constant use was made of the rich collection of native and exotic trees and shrubs. The program featured field trips to areas of botanical interest, including an all-day excursion to the New Jersey Pine Barrens. From September 20 to 23 Dr. Fogg represented the Arboretum at the twenty-second Congress of the American Horticultural Society in Cleveland. He served as moderator on "Horticultural Sources and Services for the Layman" which was held on Friday, September 22.

Dr. Frank S. Santamour, Jr., who for three years has been Geneticist on the staff of the Arboretum, accepted a position as "Research Geneticist in charge of Selection and Breeding of Shade and Ornamental Trees," at the United States National Arboretum in Washington, D.C. We extend best wishes for success in his new appointment.

Dr. Li is teaching the course, Botany 620 "Principles of Systematic Botany" and is directing the work of two graduate students. One of these is Mr. Kwok Yan Lee who has recently arrived from Hong Kong and who has been awarded the Morris Arboretum Research Fellowship for 1967-68.

Dr. Allison has complete responsibility for offering Botany 207 "Biology of the Lower Plants" which is based at the Arboretum this semester. In addition, Mr. Charles R. Jessop is working on a Research Problem on Fungi in Dr. Allison's laboratory.

It is a pleasure to announce that Mr. Paul Haeghele has agreed to serve as Curator of the Langstroth Bee Garden.

On 7, 8 September, the Director, Dr. A. O.

Dahl, had the pleasure of being an invited guest at the successful launch of Biosatellite B at Cape Kennedy, Florida. He also witnessed the spectacular launch of the lunar rocket Surveyor E some ten hours after the Biosatellite launching.

Our Plant Propagator, Mr. Bruce Keyser, in connection with the Arboretum's program on the character and significance of Witches Broom, would be most grateful for information on the location of any Witches Broom as well as possible sources of seed of such brooms.

We record with deep regret the death on 9 September of Mr. Wharton Sinkler who for many years had been a devoted member of the Advisory Board of Managers of the Arboretum.

A. Orville Dahl

Associates' Corner

THE BOT SOC IN THE PINE BARRENS

The Philadelphia Botanical Club, affectionately known to its members as the "Bot Soc", makes field trips to places in the vicinity of Philadelphia that are of botanical interest. In 1966 the Pine Barrens of New Jersey were the center of that interest, and five trips were made there.

The first trip of the year was on Sunday, February 27 to New Lisbon, N.J. The sky was clear, the temperature about 40. Patches of snow were on the ground. Fifteen cars followed the leader of the expedition along Route 38 and Magnolia Road past Magnolia Church to New Lisbon Road to Four Mile Road and parked near a blue mail-box marked "Hand". Before leaving 38, however, there was a stop on the busy highway. Everybody got out crossed the road, dodging cars, to an ordinary-looking spot where there was an ordinary-looking store, "Thompson's Lawn and Garden Supply Store." What for? We were quickly gathered to the foot of a tree on the very edge of the road. Ordinary? This is the famous black-jack oak (*Quercus marilandica*), the largest of its kind in New Jersey and as large as any in the country. It had, in fact, won high honors with the American Forestry Association which publishes the records of the big trees of the United States. We gazed in awe up into its branches and reverently

picked a dried leaf from the ground, learning to know its shape and the tiny bristles at the ends of the lobes.

Attention was drawn to a mossy bank a few feet away where Marion (young, pink-cheeked and full of knowledge) was ready to impart some of the mysteries of mosses and lichens. About twenty people went down on their hands and knees around a small green patch, trying to see, trying to learn. Some of us were satisfied to learn that the "gray goblets" and "red matches" of our childhood are lichens, not mosses, and are called *Cladonia*.

Back to the cars. New Lisbon Road took us through deep woods where we made a longer stop. We were now in a typical Pine Barren area where dry pine-and-oak woods bordered a white cedar swamp. One's feet trod crackling dried leaves or crisp pine needles, then without warning sank into spongy peat moss where the path became almost a stream. And yet there had been warning, because from a little distance back could be seen the dark pointed tops of the Pine Barren white cedar (*Chamaecyparis thyoides*) that always grows in or near the clear brown streams.

"Big Trees and Little Buds" was the title of this expedition and here they all were. So much

to learn as, pad and pencil in hand, we followed the quick steps of the leader. Winter buds of the fetter bush (*Leucothoe racemosa*), red and shining; *Itea virginica*, the Virginia willow; inkberry (*Ilex glabra*), with some of its dark berries clinging to the stem; sweet pepper bush (*Clethra alnifolia*), its graceful stems strung with dried capsules; cranberry vines trailing over the watery path, with a few hardy berries. Here is one of the Lyonias but which one? The leader's cap is spied far ahead, how to catch up, with so many people and so many briars in the way, and what have we missed while we tarried over *Lyonia*?

Then the trees. The two most characteristic pines of the Barrens, the pitch pine (*Pinus rigida*), the most abundant, and the short-leaf (*P. echinata*), are both around us and must be learned. Pitch has three needles to a bundle, short-leaf has two but, alas, sometimes three. Pitch has a more rounded top, more horizontal branches, is more unkempt. Short-leaf has a softer look, shorter needles, a spire-like top and smaller cones. Those are the facts, but *which one is that*, twenty feet away?

And the oaks. Black jack we have already met. The scrub oak (*Quercus ilicifolia*) is the next most abundant oak in the Barrens. It is smaller and has smaller leaves that are downy-white underneath. There are more oaks but these two are outstanding.

The leader's house was close to this particular walk and we were invited to eat our lunches inside or on the porch. But there was strong sunshine in the clearing by the house, so tail-gates of cars were let down and comfortable

seats were found on stones or logs for those who needed them.

One more walk was in prospect, through the woods again to the secret haunt of the climbing fern (*Lygodium palmatum*). Along this path the snow was so white, the moss so green that one felt like lingering in pure enjoyment. But at one of the moss patches there were suddenly loud cries for Marion. Someone had spied a rarity and questions had arisen. Here was another world, tiny, almost microscopic, with its own challenges and excitements. Marion appeared and down went people on their knees, some with cameras. But not all. As one man put it, "I'm not going to get involved in that. I'm too confused as it is." I think he had been struggling with his oaks. Besides black jack and scrub he had dried leaves of willow oak, chestnut oak, post, Spanish, black, and white.

The climbing fern grows near the banks of Mt. Misery Brook, a beautiful clear brown stream that flows into the Rancocas. The tallest one was about two feet, its slender stem twining around the stem of a small shrub. Both kinds of fronds were there, the fertile brown and dried, full of empty spore-cases, and the sterile, still green in February. Tiny fingers spread out from tiny hands, they seemed. It was a "first" for many of us, and unforgettable.

We walked slowly back to the clearing, with something more to learn at every step, and then it was time for the group to break up and find its various ways home. We said "Goodbye" with a strong sense of companionship in having shared a winter day in the Pine Barrens.

Phoebe Crosby

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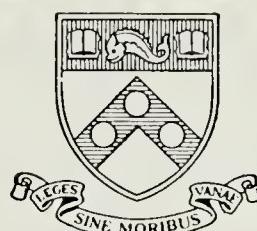
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Arboretum Activities

It is with regret that I record the demise of the once magnificent specimen of *Sophora japonica* L., the Chinese Scholar or Pagoda Tree. This specimen, said to have been planted near the Morris Mansion by Mr. Morris some 80 years ago was featured in the cover illustration of the Bulletin for September 1946. At that time the tree had a spread of 70 feet, a height of 57 feet with a trunk diameter of 36 inches. Its final trunk diameter is about 70 inches. In recent years the specimen had suffered from several years of

drought and an attack by lightning. Earlier this summer, about one-third of the tree had collapsed from what appeared to be the natural forces of gravity. The relative abundance of rainfall during the past summer promoted an unusually lush verdure which the weakened limbs could not support in the gales of a storm that occurred on 18 October 1967. The storm also severely damaged specimens of *Phellodendron*, *Cornus*, *Halesia*, *Catalpa* and, regrettably, our
(Continued on page 88)

A List of Bartram Trees and Shrubs

JOHN M. FOGG, JR.

HISTORICAL

Recently there came into my hands, through the kindness of Mrs. Drayton M. Smith of Philadelphia, a photostat copy of a document entitled, "A List of Trees and Shrubs Gathered in Pennsylvania, East and West Jersey by John Bartram, Botanist."

On a single sheet and numbered from 1 to 106 (with numbers 11 and 103 missing) are given the common or scientific names of many of the trees and shrubs which Bartram might have collected in eastern Pennsylvania and adjacent New Jersey.

John Bartram, who was born in 1699 and died in 1777, is usually regarded as America's first indigenous botanist and was certainly its most renowned explorer and horticulturist during the eighteenth century. This list which, to the best of my knowledge, has never been published is therefore worthy of our consideration.

Mr. Edwin Wolf, II, Librarian of the Library Company of Philadelphia, a recognized authority on Colonial America, also has a photostat copy of this list and has informed me that in his opinion the handwriting is not that of John Bartram but of Joseph Breintnall. Again, through the kindness of Mrs. Smith, I have been permitted to examine a sample of Breintnall's penmanship. Although the characters do not exactly match all of those in the Bartram list, the resemblance is striking and the discrepancies appear to me no greater than would be expected to occur in documents written at different stages in a man's lifetime. I am therefore strongly inclined to accept Mr. Wolf's judgment that this list was written by Breintnall.

Joseph Breintnall was an early friend of John Bartram and a fellow member of Benjamin Franklin's Junto. According to Earnest (1940), it was Breintnall who introduced Bartram to Franklin and almost certainly it was Breintnall who recommended Bartram to Peter Collinson, an English wholesale woolen merchant, as a source of supply for living plants from the New World. It is therefore not unlikely that the list in question might have served as a kind of nursery catalog of the woody plants available from the area then familiar to Bartram.

Since Breintnall died in March, 1746, it is pertinent to ascertain the nature and extent of

Bartram's travels between 1731, when he established his garden on the banks of the Schuylkill River, and that date. The following account is taken largely from an article by R. H. True which appeared in *Bartonia* in 1931. Darlington's "Memorials of John Bartram and Humphrey Marshall" (1849) which contains much of Bartram's correspondence with his friends abroad, has also been consulted.

In 1735 at the suggestion of his friend, Collinson, Bartram followed the Schuylkill River to its source, thus becoming familiar with a large portion of southeastern Pennsylvania. In 1736 he visited the Rattlesnake Mountains and explored "the Jerseys." It is reasonable to assume that on this trip he would have seen many of the plants of the world-famous Pine Barrens of southern New Jersey.

Reference to "the Jerseys" is worthy of comment, especially since the title of this document refers to "East and West Jersey." The line dividing New Jersey into east and west sections extended in a northwesterly direction from Little Egg Harbor. It was established in 1676 and persisted until 1738, at which date all of New Jersey was united under a provincial governor. Even after that date, however, reference continued to be made to "the Jerseys" and the boundary appeared on maps printed in the mid to late eighteenth century.

In 1737 Bartram traveled west to the Conestoga River and in the fall of that year he journeyed southward through Delaware and Maryland to Williamsburg, Virginia, returning by way of the Shenandoah Valley. Between 1738 and 1742, he engaged in various excursions throughout eastern Pennsylvania, southeastern New York and southern New Jersey.

In 1743 Bartram accompanied Conrad Weiser on a long journey across the Blue Mountains to the Onondaga country in western New York. He thus would have seen several of the species of a more northerly distribution which appear in the present list. If we are correct in assuming that this list is in Breintnall's handwriting, then Bartram's travels later than 1746, including his expeditions to the Carolinas and Georgia, need not be considered here.

According to Barnhardt (1931), only about 300 American plants were in cultivation in England before 1734, when John Bartram made his first



Fig. 63. John Bartram's house, built with his own hands in 1731.

known shipment. Between 1736 and the time when the Revolutionary War interrupted the traffic, this number had more than doubled and Barnhardt surmises that Bartram was responsible for the introduction into England of between 150 and 200 species of American plants. It is no wonder, then, that this self-educated farmer enjoyed so exalted a reputation and that horticulturists such as Peter Collinson, Dr. John Fothergill and Philip Miller relied upon him for botanical novelties from the New World. His correspondents also included such eminent botanists as Linnaeus, Gronovius and Dillenius.

THE LIST

It should be borne in mind that the present list was almost certainly composed before the appearance of the *Species Plantarum* of Linnaeus (1753) and his *Genera Plantarum*, Ed. 5 (1754) which together serve as the starting point for our modern binomial nomenclature. This will explain the occasional inclusion of polynomials, such as No. 52—*Toxicodendron Folia Pinatum*.

For the most part, however, the names used in the list are in the vernacular and several of them, such as No. 22—*Lotus Arbor* and No. 59—*Benjamin*, are no longer familiar to us. In an effort to identify some of these obscure references, I have consulted several of the works which would have been available to Bartram. We know from his correspondence with Collinson that Bartram's library contained, among others, such volumes as Parkinson's "Herbal," Philip Miller's "Dictionary," the "Systema Naturae" of Linnaeus, and the "Flora Virginica" of Gronovius, which was based upon collections made by John Clayton in Gloucester County, Virginia. These works, however, shed very little light upon the application of the names in the list. A careful perusal of the Bartram-Collinson correspondence, as published in Darlington's "Memorials," has solved several

of the problems, but there are still instances in which I have simply had to guess at the meaning of the original name. It is entirely possible that I have failed completely to interpret some of them; and, if such is the case, I shall be happy to be corrected by anyone who possesses a better understanding of plant names used in America during the eighteenth century.

In the list which follows, the number and name of each plant are given exactly as they appear in the manuscript. I have then supplied the scientific name (except where this is of doubtful application) and the presently accepted common name or names (except when these are the same as those given in the list). Additional comments are offered when it seemed that they might serve to clarify my efforts to interpret Bartram's terminology after the passage of more than two centuries.

1. Tulip Tree. *Liriodendron Tulipifera* L.
2. Ld. Weymouth's Pine. *Pinus Strobus* L. Eastern White Pine. This tree derives its common British name from the fact that it was planted at Longleat, England, early in the eighteenth century by Lord Weymouth. This is a northern species which was unknown in southeastern Pennsylvania until introduced there. If Bartram saw it growing in the wild, it must have been either in northeastern Pennsylvania or northern New Jersey.
3. Three leaf'd Pine (Two Sorts). This may refer to *P. rigida* Mill., pitch pine, which is variable as to habit, length of needles, and size and time of opening of cones. It must also be taken into account that, since Bartram visited Cape May County, N.J., he may conceivably have seen and collected two other three-needed species; namely *P. Taeda* L., the loblolly pine, and *P. serotina* Michx, the pond pine. Both of these, however, are extremely rare and may not even be native to the area.
4. Two & three leaf'd Pine. *P. echinata* Mill. Yellow or short-leaf pine. This species which is of common occurrence, especially in southern New Jersey, differs from other local pines in that the number of leaves in a fascicle varies between two and three.
5. Dwarf Pine of the Desert. There would seem to be little doubt that what is here referred to is the spectacular growth of stunted *P. rigida* which occurs in what is today called the pitch-pine plains of southern New Jersey. This area, which occupies portions of Burlington and Ocean Counties, has been carefully studied by Lutz (1934).

6. Two-leaved, or Tough Pine. *P. virginiana* Mill. Jersey pine or scrub pine. The only consistently two-needed pine which Bartram would have been likely to find. It seems improbable that he would have known *P. resinosa* Ait., the red pine, which occurs only at a few stations in northeastern Pennsylvania or *P. pungens* Lamb., the Table Mt. pine, which reaches its northern limit in several of the south-central counties.

7. Great Mountain Magnolia. *Magnolia acuminata* L. Cucumber tree or cucumber magnolia. The most wide-ranging species of this genus and the largest in the area here considered.

8. Swamp Magnolia. *M. virginiana* L. Sweetbay or laurel magnolia. A handsome large shrub or small tree which occurs in swamps or low woods from Massachusetts south to Florida and the Gulf States.

9. Great Cluster Cherry. *Prunus serotina* Ehrh. If the term "cluster" may be interpreted to mean that the flowers are borne in racemes, rather than solitary or in corymbs, then there can be little doubt concerning the identity of this and the following species. *P. serotina*, the black or rum cherry may achieve a height of 30 m. (100 feet) and is common throughout the area.

10. Dwarf Cluster Cherry. *P. virginiana* L. Choke-cherry. A large shrub or small tree to 10 m. which usually blooms and matures its fruit two or three weeks before the preceding species.

12. Siliquastrum. *Cercis canadensis* L. Redbud or Judas-tree. Bartram's use of the epithet "Siliquastrum" derives from the specific name of the European red-bud of which ours was for a time considered to be merely a variety.

13. Sassafras. *Sassafras albidum* (Nutt.) Nees. Sassafras.

14. Tupelo. *Nyssa sylvatica* Marsh. Black-gum, sour-gum or tupelo.

15. Myrtle. This may refer to *Leiophyllum buxifolium* (Berg.) Ell., an evergreen Ericaceous shrub of the Pine Barrens which we know that Bartram sent to his friends in England. It is also possible that what is intended is *Myrica cerifera* L., the wax-myrtle which reaches the northern limit of its range in southern New Jersey.

16. Pawpaw. *Asimina triloba* (L.) Dunal.

17. Evergreen Privet. *Ilex glabra* (L.) Gray. Inkberry, gallberry. In writing to Peter Collinson on January 6, 1763, Bartram says, "Evergreen Prinos is what I call Evergreen Privet, or Inkberries, in New Jersey." (Memorials, p. 246.)

18. Evergreen Jersey Tea. *Ledum groenlandicum* Oeder. Labrador Tea. This boreal species reaches its southern limit in the bogs of northeastern Pennsylvania and northern New Jersey, where Bartram may well have seen it. Another possibility is *Gaultheria procumbens* L. wintergreen or teaberry, which Marshalls (1785) refers to as "Mountain Tea."

19. Pensylv. Elder. Probably *Sambucus canadensis* L. Common Elder. If Bartram had meant *S. pubens* Michx., the red-berried elder, he probably would have referred to it by that name.

20. Newfoundland Spruce Fir. *Tsuga canadensis* (L.) Carr. Eastern Hemlock. Collinson, writing to Bartram, March 14, 1736-7, states, "I take it your Spruce is certainly Dudley's Hemlock Fir, which is here called Yew-leaved Fir." (Memorials, p. 93.) The application of the term "Spruce" to our eastern hemlock has survived until comparatively recent times. Britton (1881) refers to *Abies Canadensis*, Michx. as Hemlock Spruce.

21. Black Mulberries. If we are to assume that the plants on Bartram's list were native to the area, then the reference here is probably to *Morus rubra* L., the fruits of which are dark purple or even blackish. According to Baxter (1931), *M. rubra* was growing in Bartram's garden in 1923. *M. nigra* L., the black mulberry, is a native of Asia.

22. Lotus Arbor. *Celtis occidentalis* L. Hackberry, Sugarberry. Celtis, the name given by Pliny to a species of Lotus, was adopted by Tournefort and later by Linnaeus for this genus. See Sargent, Silva, Vol. 7:65. In Species Plantarum, Ed. 1 (1753), the European *C. australis* is called *C. Lotus*, p. 1044.

23. Red flowering Maple. *Acer rubrum* L. Red Maple.

24. Silver leaf'd Maple. *A. saccharinum* L. Silver Maple.

25. Dwarf Mountain Maple. *A. spicatum* Lam. Mountain Maple.



Fig. 64. The stone cider press in Bartram's Garden

26. Black Birch. Probably *Betula lenta* L., which is usually known as cherry birch or sweet birch. *B. nigra* L., which Bartram must also have known, is generally referred to as red birch or river birch.

27. Poplar-leaf'd Birch. *B. populifolia* Marsh. Gray birch.

28. Paper Birch. *B. papyrifera* Marsh. Also called canoe birch or white birch. This is a species of a more northerly distribution which Bartram would have seen in his travels to the mountains of Pennsylvania or northern New Jersey.

29. Arbor Vita. *Thuja occidentalis* L. Arbor Vitae. Another species which Bartram could have found only in the northern counties of Pennsylvania or New Jersey.

The Bartram list contains the names of 17 oaks (Nos. 30 to 46), several of which are not only unfamiliar to us but do not appear in contemporary works. One is led to suspect that Bartram manufactured some of them and was their only user. It is also possible that he recognized more species of oaks than were accepted by later botanists. In a letter to Bartram dated February 13, 1753, Peter Collinson made the following observations: "I am afraid the species are so multiplied that it will be a difficult task to distinguish them here. . . The difference between the Lowland White Oak [*Quercus bicolor* Willd.?] and the Mountain White Oak [*Q. obtusiloba* Mx.?] is purely owing to their situation. . . and the like may be in the Swamp and Mountain Chestnut Oak [*Q. Prinus* L. and *Q. montana* Willd.?], a difference owing to soil and situation—not sufficient to constitute two distinct species; and so of the Spanish and Swamp Spanish Oak [*Q. falcata* and *Q. palustris* of Mx?]. I know this tribe of trees sport so, in their leaves, that it is easy for thee to collect specimens that shall have a great appearance of a distinct species; but the question is, will this hold through the forest?" The bracketed names above were supplied by Darlington (Memorials, 190) who furnishes the following footnote: "Friend Collinson manifests a laudable desire to avoid the unnecessary multiplication of species; but the modern botanists, generally, have sustained the views of John Bartram, in reference to the specific differences of the Oaks here mentioned."

It is interesting that Collinson, who never set foot on American soil, should have been so keenly aware of the taxonomic difficulties which confront the student of this genus. It is also significant that William Darlington, writing in 1849, should have come to Bartram's defense in up-

holding his interpretation of this most complex group of eastern American trees.

Whether Bartram was deceived by minor taxonomic or ecological variations, or was ignorant of the known tendency of various species of *Quercus* to produce hybrids, it is still noteworthy that, within the restricted area of this list, he was able to designate 17 different kinds—and this, apparently, before such species as *Q. macrocarpa* and *Q. laurifolia* had been discovered.

Because of the ambiguities inherent in this situation, I have elected to provide Latin names only for those species which seemed to me unequivocal. Where a reasonable guess seemed justified, I have appended a scientific epithet followed by a question mark. In a few cases, however, I have permitted Bartram's name to stand alone, hoping that someone with a fuller knowledge of our native oaks would be able to provide the correct name.

30. Great Mountain Chestnut Oak. *Quercus Prinns* L. (*Q. moutana* Willd.) Chestnut oak.

31. Great Swamp Chestnut Oak. *Q. bicolor* Willd. Swamp-white oak.

32. Highland Spanish Oak. Possibly *Q. palustris* Muenchh., although this name seems more applicable to No. 38.

33. Swamp Spanish Oak. *Q. falcata* Michx. Spanish oak. I am following Gray's Manual, Ed. 8, in the application of the names of the red and Spanish oaks.

34. Great Champain Red Oak. *Q. rubra* L. Red oak. (See note above.) The use of the term "champain", presumably denoting "field" (in contrast to "mountain" or "swamp") is certainly not commonly met with in eighteenth century works.

35. Great White Oak. *Q. alba* L. White oak.

36. Scrubby White Oak. *Q. stellata* Wang.? Post oak. A small tree (formerly known as *Q. obtusiloba* Michx.) with which Bartram would certainly have been familiar.

37. Willow leaf'd Oak. *Q. Phellos* L. Willow oak. A species confined to the Atlantic Coastal Plain which Bartram would have encountered on his numerous trips to southern New Jersey.

38. Scarlet Lowland Oak. *Q. palustris* Muenchh. Pin Oak. I can think of no other species which would fit Bartram's name, and yet it might with equal reason be applied to No. 32.

39. Great Barren Black Oak. *Q. marilandica* Muenchh. Black-Jack oak, Barren oak. The adjective "great" may seem inappropriate as applied to this small tree or coarse shrub, but it is difficult to assign Bartram's name to any other

species. It is conceivable that "great" here modifies "Barren" rather than "Oak," since this species is of frequent occurrence both in the Pine Barrens and on the Serpentine Barrens.

40. Champain Great Black Oak. *Q. velutina* Lam. Black oak.

41. Broad leaf'd Willow Oak. *Q. imbricaria* Michx.? Shingle oak. Although this species is unknown in the wild in eastern Pennsylvania, it is possible that Bartram may have seen it on his travels farther north and west. The other alternative would seem to be *Q. laurifolia* Michx., a southern species which reaches its northern limit in Cape May County.

42. Bastard Champain Red Oak. *Q. coccinea* Muenchh.? Scarlet oak.

43. Dwarf Scarlet Oak. *Q. ilicifolia* Wang.? Bear-oak, scrub-oak.

44. Dwarf Black Oak.

45. Dwarf Chestnut Oak. *Q. prinoides* Willd. Also called Chinquapin-oak.

46. Dwarf White Oak (very rare).

47. Great Round-leaf'd Viburnum. *V. alnifolium* Marsh. Hobble-bush. A shrub of northerly distribution which Bartram would have seen in the mountains of Pennsylvania or northern New Jersey.

48. Tough-twig'd Evergreen Viburnum. While no American viburnum is completely evergreen, several of them retain their foliage well into late autumn or early winter. The reference here may well be to *V. nudum* L., possum- or swamp-haw, which is common in swampy woods and wet pine-lands throughout Bartram's area. *V. Lentago* L. also has somewhat persistent leaves, but is less likely to have been seen by Bartram.

49. Dwarf Mountain Viburnum. Probably *V. acerifolium* L. Arrow-wood, maple-leaved viburnum. A low-growing, wide-ranging species of the mountains as well as the lowlands. Marshall (p. 162) refers to *Viburnum triloba* (sic) as Mountain Viburnum and that may also be what is meant here.

50. Oval serated leaf'd Viburnum. Probably one of the complex which in Bartram's time would have been known as *V. dentatum* L., but which today has undergone segregation into such species as *V. recognitum* Fern. and *V. Rafinesquianum* Schultes.

51. Great Spiney Viburnum. *V. prunifolium* L. Black-haw. The tallest and coarsest of our native species.

52. Toxicodendron Folia Pinatum. *Rhus Vernix* L. Poison sumac, poison elder. A tree of swampy woods throughout the area known to Bartram.

53. Red Cedar. *Juniperus virginiana* L.

54. White Cedar. *Chamaecyparis thyoides* (L.) BSP. A tree of swamps and bogs especially common in southern New Jersey.

55. White Ash. *Fraxinus americana* L.

56. Black Ash. *F. nigra* Marsh.

57. Red Ash. *F. pensylvanica* Marsh.

58. Prinos. *Ilex verticillata* (L.) Gray. Black alder, winterberry. Although *Prinos* today is applied to a section of *Ilex*, distinguished by having the nutlets of the drupes smooth rather than ribbed, it was formerly used at the generic level. Linnaeus (1753) referred to the present species as *Prinos verticillata* and this usage continued well into the nineteenth century; see, e.g., Darlington's *Flora Cestrica* (1837). Parenthetically, it seems strange that the list contains no reference to American holly, *Ilex opaca* Ait.

59. Benjamin. *Lindera Benzoin* (L.) Blume. Spicebush. While probably less familiar than spicebush, the term "Benjamin" is still occasionally used for this species, e.g., Gray's *Manual*, Ed. 8.

60. Dogwood. *Cornus florida* L.

61. Great Chamaerhododendron. *Rhododendron maximum* L. Great laurel, rosebay.

Because of our lack of familiarity with Bartram's names, Nos. 62 to 68 present something of a problem; my identifications must be regarded as guesses, subject to correction.

62. Lesser Chamaerhododendron. *Kalmia latifolia* L. Mountain-laurel, calico-bush. In writing to Bartram, Collinson frequently refers to this plant as "Ivy," a name which does not appear in the list.

63. Olive-leaf'd Chamaerhododendron. *K. angustifolia* L. Sheep-laurel, lambkill.

64. Thyme-leaf'd Chamaerhododendron. *K. polifolia* Wang. Pale or bog-laurel. A species of the far north which reaches its southern limit in northeastern Pennsylvania and northern New Jersey.

65. Broad leaf'd Andromeda. *Lyonia mariana* (L.) D. Don. Stagger-bush. Both *Lyonia* and *Leucothoe* were formerly referred to as *Andromeda*.

66. Boggy Andromeda. *Audromeda glaucocephala* Link. Bog-Rosemary. A bog species with a range similar to No. 64. It is also possible that what is meant here may be *Chamaedaphne calyculata* (L.) Moench, the leatherleaf which is so common in Jersey bogs and swamps.

67. Tall Spiked Andromeda. *Lyonia ligustrina* (L.) DC. Maleberry, privet andromeda.

68. Red bud'd Andromeda. *Leucothoe racemosa* (L.) Gray. Fetter-bush. See note under No. 65.
69. Uva-Ursi, or Evergreen Rhamnus. *Arctostaphylos Uva-ursi* (L.) Spreng. Bearberry, mealyberry.
70. Downy Sumach. *Rhus typhina* L. Staghorn or velvet sumac.
71. Beech Sumach. Lentis folio. *Rhus copallina* L., dwarf or shining sumac. Although the term "Beech" is somewhat obscure, the clue to the identity of this species will be found in Marshall (p. 128) where *Rhus copallinum* (sic) is referred to as "Lentiscus-leaved Sumach." *Lentiscus* is an earlier name for *Pistacia*, a member of the same family as *Rhus*.
72. Common Sumach. *R. glabra* L. Smooth or upland sumac.
73. Sweet flow'ring Locust Acacia. *Robinia Pseudo-Acacia* L. Black locust. This species is not considered indigenous to the area east of the Appalachian Mts. (see, e.g., Darlington, 1837, p. 410); but, according to Rehder (1940), was introduced into cultivation in 1635. It was widely planted for the beauty and fragrance of its flowers and the durability of its wood and has become freely naturalized.
74. Honey Locust. *Gleditsia triacanthos* L. Like the preceding, this species is native to the region west of the Appalachian Mts., but was introduced eastward about 1700.
75. Cephalanthus. *Cephalanthus occidentalis* L. Button-bush.
76. Ceanothus. *Ceanothus americanus* L. New Jersey-tea. A deciduous shrub, not to be confused with No. 18.
77. Silver-leaf'd Alder. *Alnus rugosa* (DuRoi) Spreng. Speckled Alder. Formerly called *A. incana* (L.) Moench. because of the whitened under-surfaces of the leaves.
78. Common Alder. *A. serrulata* (Ait.) Willd. Formerly known as *A. rugosa* of most American authors, not Spreng.
79. Bleuberried Cornus femi. Probably *Cornus Amomum* Mill. Silky cornel, kinnikinnick. Although *C. rugosa* Lam. also has blue fruit, it is a northerly species which would not have been as familiar to Bartram as *C. Amomum*. The term "femi" (which appears in the combinations of some authors as "foemina") was apparently applied to certain dogwoods in the mistaken belief that they were female, as opposed to the male *C. florida*.
80. White berried Corus femi. Probably *C. racemosa* Lam. (*C. pauciflora* L'Her., *C. candidissima* Marsh.) Grey Cornel. While *C. stolonifera* Michx. also has white fruits, it would have been far less frequent in the area readily available to Bartram.
81. Clethra. *Clethra alnifolia* L. Sweet pepper-bush, summer-sweet.
82. Hydrangea. *Hydrangea arborescens* L. Although several other members of this genus occur in the southeastern states, this is the only species which Bartram would have encountered locally.
83. Purple Spirea. *Spiraea tomentosa* L. Steeple-bush, hard-hack.
84. White Spirea. Probably either *Spiraea alba* DuRoi or *S. latifolia* (Ait.) Boush., although some doubt now exists as to whether these two are distinct species.
85. Spirea opulifolio. *Physocarpus opulifolius* (L.) Maxim. Ninebark.
86. Great broad leaf'd Euonimos. *Euonymus atropurpureus* Jacq. Burning-bush, wahoo.
87. Evergreen Euonimos. Since no eastern American species of *Euonymus* is truly evergreen, this reference is somewhat obscure; it may possibly relate to *E. americanus* L., strawberry-bush or bursting-heart, in which the leaves are thickish, although not actually persistent. Such Old World evergreen species as *E. japonicus* and *E. Fortunei* (both widely cultivated and tending to become naturalized) were not introduced into America until after the beginning of the nineteenth century.
88. Early Sweet-service. There are several species of *Amelanchier* (shad-bush, June-berry, service-berry) which might have been known to Bartram. Contemporary works usually list only *A. Botryapium*, which according to present treatments might have been either *A. canadensis* (L.) Medic or *A. arborea* (Michx. f.) Fern. The term 'service' was also formerly applied to various species of *Crataegus*.
89. Highland Roses. Of the various species of *Rosa* which might answer this description, *R. virginiana* Mill. and *R. carolina* L. seem the most likely.
90. Marsh Roses. *Rosa palustris* Marsh. would appear to be the only native eastern species commonly found in moist habitats.
91. Wild Honeysuckle. *Rhododendron nudiflorum* (L.) Torr. Although more correctly known as pinxter-flower, this species is still occasionally referred to as wild honeysuckle.
92. Shrub St. John's Wort. Probably *Hypericum densiflorum* Pursh. Shrubby St. John's-wort. *H. spathulatum* (Spach) Steud. (*H. prolificum* Am. auct.) is also shrubby, but is of less frequent occurrence in this area. Another shrubby species is *H. Kalmianum* L., but its range lies to the west

and south of the region encompassed in this list.

93. Euonimos Scandens. *Celastrus scandens* L. Climbing bittersweet.

94. Dwarf Cratagus. Probably *Crataegus uniflora* Muenchh., a shrub or small tree of fairly frequent occurrence on the siliceous soils of the coastal plain.

95. Vitis Idea, (very late ripe). At first sight, this would appear to be *Vaccinium Vitis-idaea* L., the mountain-cranberry, which ripens late in the year and is said to possess a superior taste after it has lain under the snow. However, this sub-arctic species reaches its southern limit in New England; and, if we are to interpret the heading of this list literally, could scarcely have been collected by Bartram. The only alternative would seem to be a late-fruiting species of grape, such as *Vitis aestivalis* Michx. or *V. riparia* Michx.

96. Senecio Arborescens. *Baccharis halimifolia* L. Groundselbush. Among the synonyms of this species cited in Linnaeus (1753) is *Senecio virginianus arborescens*.

97. Sweet soft-shelled Hickory. Probably *Carya ovalis* (Wang.) Sarg. Sweet Pignut.

98. Sweet Gum or liquid Amber. *Liquidambar Styraciflua* L. Sweet gum.

99. Sweet gall. Although the second word is very clearly spelled with two "l's" in the manuscript, this would seem to be an error. The noun and the adjective are incompatible and one is compelled to suggest that what is intended here is sweet "gale," *Myrica Gale* L., which Bartram could have seen in northeastern Pennsylvania or northern New Jersey.

100. Black Walnuts. *Juglans nigra* L.

101. Hammamelis. *Hamamelis virginiana* L. Witch Hazel.

102. White Walnuts. *Juglans cinerea* L. Butternut.

104. Narrow-leaf'd Thorn. In a genus as large and taxonomically complex as *Crataegus*, it would be out of the question to determine what is intended here. One can only hazard a guess that it might have been *C. crus-galli* L., cockspur thorn.

105. Aralia spino. *Aralia spinosa* L. Hercules'-club, Devil's walking stick.

106. Pig Nuts.- (very bitter). Probably *Carya glabra* (Mill.) Sweet, although *C. cordiformis* (Wang.). K. Koch is also known as pignut.

One of the perplexing features of this list is the omission of several genera of trees and shrubs which must have been well known to Bartram, e.g., *Carpinus*, *Castanea*, *Chiouauthus*, *Corylus*, *Diospyros*, *Dirca*, *Fagus*, *Ostrya*, *Platanus*, *Populus*, *Salix*, *Staphylea*, *Tilia*, and *Ulmus*. One can

merely conclude that this was not intended to be a complete listing of the woody plants available to Bartram from this area.

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Notes on Pine Resins and Pest Resistance

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ABSTRACT

Original observations are made concerning resin canal systems, resin acids, and resin crystallization. The relationship between pine resins and pest resistance is briefly reviewed and some new ideas for further research are proposed.

Pine trees are notable, although not unique, for producing significant amounts of resins in various vegetative and reproductive organs. Generally speaking, these resins are secondary metabolic products and have no known function in the plant. Like many other secondary plant products, resins have been considered to be important in protecting the plant from injurious agencies, such as insects. However, the role of resins in protection is more than speculative, and some recent studies have demonstrated a clear relationship between resin characteristics and pest resistance.

From about 1962 to 1967, while employed by both the U.S. Forest Service and the Morris Arboretum of the University of Pennsylvania (1964-67), I carried out several studies on pine resins. The principal objective of these studies was to determine the relationship between resin characteristics and resistance to insects. The white pines were studied almost exclusively and the primary insects were the white-pine weevil and the white-pine cone beetle.

During this period, the resin studies were not my major concern, and the work was sporadic. Some of the results have been published (Santamour 1965 a, b) but a number of observations have never been reported. The resin work was terminated in July, 1967, when I left the Morris Arboretum, and it is unlikely that I shall be concerned with pine resins in the future.

This paper is an attempt to summarize my more interesting and/or important findings in the hope that they may be useful in stimulating further research into the resin-pest relationship.

PINE OLEORESINS

The resins of pines are more properly termed "oleoresins" and are defined by the American Society for Testing Materials as "pine gum, the nonaqueous secretion of resin acids dissolved in a terpene hydrocarbon oil which is (1) produced in or exuded from the intercellular resin ducts of a living tree. . ." Actually, the solvent is not always terpene and the dissolved material is not

completely made up of resin acids. The terpenes or other solvents are volatile and are distilled off as turpentine—the residue is called rosin.

RESIN CANAL SYSTEMS

Resin canals are formed shizogenously in intercellular spaces and are lined with epithelial parenchyma cells that secrete resin. In the wood (xylem), resin canals exist in both the vertical and horizontal systems, and may be produced in response to injury (such as tapping the tree for resin). Other separate and distinct canal systems occur in the needles, cones, and cortex.

Larvae of the white-pine weevil are most active in the cortex. Thus, the cortical resin canals were considered to be most important from the standpoint of weevil resistance. It is well known that the cortex ("bark") of young white pine stems contains two concentric longitudinal canal systems. Sacher (1954) found, in sugar pine, that both series of canals were continuous within an internode (broad sense—one year's shoot extension) but that no lateral connections were formed between the two systems. The canals of the inner series are formed earlier and are considerably larger than those of the outer series. Branch canals arise from both series: those from the inner series differentiate into the cataphylls, while those from the outer series extend into the dwarf shoots and lateral branches.

The major unanswered question, as I saw it, was whether the cortical canals were continuous from one year's growth to another. Any discontinuity might influence resin chemistry and resin flow.

Stem sections, six to eight inches long, were cut from *Pinus Griffithii* and *P. Strobus* and immersed in toluene to dissolve the resin. These sections contained portions of two year's growth and the branch whorl between them. Sections were left in the toluene for seven days, during which time the resin canals were periodically cleared by air pressure through the section. The first test of resin canal continuity involved blowing smoke through the section. It works! After the sections were completely dry, the cortical tissue was carefully shaved with a single-edge

¹ Research Geneticist, U. S. National Arboretum, Washington, D.C. 20250

razor blade to expose the resin canals. It was found that some of the inner canals were continuous through the branch whorl. This continuity could be demonstrated only in cases where the whorl contained few branches. It is likely that an increase in branch number or size at the whorl might cause discontinuities in the canal system.

One of the implications of the continuity of cortical resin canals is that the chemical composition of resin should be similar at any point in the cortex. This hypothesis should be checked. Does resin flow within the canals? Would material introduced into the resin canals diffuse through the resin from year to year? As a matter of pure speculation, it might be possible to introduce insecticides into the resin system to "immunize" a tree against insect attack for several years. I tried to introduce dyes into the canals by topically applying material dissolved in pine oil and dimethylsulfoxide (DMSO) and succeeded only in girdling the branch. However, there is much to be learned about resin canal systems and further work may yield significant rewards.

RESIN ACIDS

The resin acids are a related group of 10 to 14 monobasic acids that have the empirical formula $C_{20}H_{30}O_2$. These acids have been little studied outside the Naval Stores industry, and therefore details of composition have been reported only for the wood resins of principal turpentine-producing pine species. Basically, the acids are of two general types, abietic and pimaric, and there is a strong tendency for isomerization within these types. Resin acids constitute the greatest portion of the non-volatile fraction of oleoresin, and are probably important in the natural and insect-induced crystallization of resins (discussed below).

Total acids were determined in several ways. The first method was a process patented by Ridgway (1957) that depended on the insolubility of the resin acids in nitroalkanes. Nitroethane appeared to be the best of the alkanes but, while the purity of the acids was acceptable, the yields were lower than might be expected. The second technique was that of Harris and Sanderson (1948). They reported the "nearly quantitative" precipitation of resin acids as insoluble cyclohexylamine salts from oleoresin. The amine salts could be converted to pure acids or esters for further analysis. The cyclohexylamine method proved to be the most satisfactory of the wet chemical techniques. Percentage of resin acids obtained by the two methods from various resins of two pine species are given below:

	<i>Nitroalkane</i>	<i>Cyclohexylamine</i>
<i>P. Strobus</i>		
Wood	7	49
Cortex	22	61
<i>P. Griffithii</i>		
Wood	20	42
Cortex	0	21

In most instances, titration with sodium hydroxide gave higher estimates of total resin acids than either of the above methods. It is probable that the presence of small quantities of acids of low molecular weight could drastically alter titration results.

Both qualitative and quantitative data were obtained by gas-liquid chromatography of methyl esters of the resin acids. These tests were run at the Naval Stores Research Station, ARS, Olustee, Florida through the courtesy of Drs. Ray V. Lawrence and N. Mason Joye, Jr. Results of some of these tests are given in Table I.

Table I—Resin acids of several pine resins, as percentage of total resin acids.

Resin Acid ¹	<i>P. Strobus</i>	<i>P. Griffithii</i>
	Wood percent	Cortex percent
Unknown #1	0.4	—
Elliotinoic	11.8	—
Pimaric	6.7	10.2
Sandaracopimaric	3.5	7.1
Palustric and Levopimaric	14.4	8.5
Isopimaric	22.8	15.0
Unknown #2	—	37.1
Dehydroabietic	0.4	3.2
Abietic	26.5	7.3
Neoabietic	12.7	7.1
Unknown #3	—	1.5
Unknown #4	—	3.0
		2.3

¹ Acids are listed in the order of their relative responses (1.86 to 6.16) using a methyl stearate marker as 1.00.

The major points to be seen in the table are (1) difference between types of resin within *P. Strobus*, (2) difference between cortical resins of *P. Strobus* and *P. Griffithii*, and (3) the large proportion of "Unknowns" in cortical resins. These data demonstrate that more intensive study of pine resin acids is needed before we can make meaningful correlations between acid content and pest behavior. The identification of Unknown #2, the principal acid in cortical resins, would be an important step in furthering resin research.

Quantitative data obtained by chromatography on total resin acid content of oleoresins did not agree with either precipitation technique described above or with titrations. A critical evaluation of techniques for total acid determinations is needed.

TERPENES

More work has been done on the relationship between insects and terpenes than with any other resin component. The U.S. Forest Service, Pacific Southwest Forest and Range Experiment Station, has led in this work. Mirov (1961) published a compilation of his findings on the terpenes of some 94 species and varieties of pines. Smith (1964) has continued these studies and, furthermore, has related terpenes with resistance to bark beetles and the pine reproduction weevil (Smith 1960, 1961). The California work has been concerned primarily with wood resins. H. D. Gerhold, Pennsylvania State University, is studying terpenes of cortical resin in relation to resistance of pines to white-pine weevil.

Santamour (1965 a) pointed out that the terpene chemistry of resins may vary greatly depending on their source. In *P. Griffithii*, the terpenes of cortical resin were markedly different from those of wood resin, while the two resin types were similar in *P. Strobus*. Squillace and Fisher (1966) also found differences in wood and cortical resin of splash pine. Thus it is imperative that the proper resins be taken into account when dealing with insects that attack different plant tissues or organs.

Although terpenes have been most studied from the viewpoint of insect resistance, it is possible that they may influence other pests as well. For instance, Santamour *et al* (1963) attempted to relate wood terpenes of several hard pines to significant differences in damage caused by field mice. It would also be interesting to determine the effect of terpenes on certain fungi. Both insect types being studied by Smith are associated with fungi that are carried by the insect and may

aid in the destruction of the plant. The influence of resin components on the blue-stain fungi (*Ceratocystis* spp.) associated with bark beetles and *Hormiscium gelatinosum* associated with the pine reproduction weevil might play a part in "insect" resistance.

OTHER COMPOUNDS

Santamour (1965 a) reported on the incomplete solubility of cortical resins of certain white pines in methanol, ethanol, and acetone. The white, amorphous, insoluble material (1 percent by weight) was isolated and found to contain hydroxyl groups and many aliphatic carbons—the melting point was 290° C. Cortical resins of 17 pine species of both subgenera were boiled with methanol to determine the presence of this substance. Only *P. rigida*, *P. resinosa* and *P. Banksiana* gave questionable results. Wood resins generally tested negative for this substance, but it was found in one of three *P. parviflora* trees and in a putative natural hybrid between *P. Griffithii* and *P. parviflora*.

RESIN CRYSTALLIZATION

The crystallization of resins is the result of the precipitation of resin acids from a supersaturated solution, combined with an evaporation of the terpene solvent. However, not all resins will crystallize naturally, or when acted upon by animal or chemical agents.

NATURAL CRYSTALLIZATION

Natural crystallization of oleoresin is probably dependent on both the total resin acid content and the relative proportions of the various acids. Baldwin *et al* (1958) stated that crystallization of a given resin acid from rosin (residues left after steam distillation of turpentine) may occur when the resin acid makes up about 30 percent of the weight of the rosin, and the crystallization of one acid will bring down other acids. It is possible that a similar situation pertains in oleoresin. Resins vary in their capacity for crystallization depending on the species and organ from which they were collected. Furthermore, there is a distinct relationship between natural crystallization and crystallization induced by insects.

INSECT-INDUCED CRYSTALLIZATION

Several studies (Harris 1960; Yates 1962, 1968; Santamour 1965 a, b) have been concerned with the role of certain insects in causing or stimulating the crystallization of oleoresins. Only the cortical resin, as opposed to wood resin, has been shown to undergo the crystallization reaction with insects. The above studies have pointed out the possibilities of utilizing the crystallization

reaction as a test of susceptibility to insects that attack young branches, buds, or even cones.

From recent work with the white-pine cone beetle, it appeared that insect-induced crystallization was not entirely dependent on total resin acid content of oleoresins. Of two cortical *P. Strobus* resins, both with 61 percent acids, one crystallized readily while the other resisted crystallization. Two hybrids between a crystallizable *P. Strobus* and a non-crystallizing *P. Griffithii* average 48 percent acids and were readily crystallized. Further tests showed crystallization with *P. parviflora* (78 percent), but no crystallization in *P. reflexa* (50 percent) or *P. Lambertiana* (37 percent). If the total resin acid content is not a critical factor in crystallization, it may be that specific acids are responsible for the phenomenon. The reaction causing or enhancing crystallization is probably chemical, and certain chemicals associated with insects are known to react with certain resin acids.

Some Coleoptera may produce toxic substances, such as quinones, as defensive mechanisms or population buffers (Roth and Eisner 1962). Larvae of both the white-pine weevil and the white-pine cone beetle were tested for toxic secretions but none were found. Further observations indicated that there was no specific and directed response by the insect to cause crystallization. Rather, the induction of crystallization appeared to result as a passive feature of the insect's activity. For instance, it was noted that when a live adult cone beetle or weevil larva was allowed to crawl through a thin film of reactive resin, crystals would frequently be formed along the insect's path. Mechanical agitation of the resin did not yield crystals. Furthermore, small amounts of a yellow amorphous substance were occasionally found on the feet or body of an adult beetle. This yellow material, when crushed and stirred into a resin droplet, brought about far more rapid and extensive crystallization than the normal test procedure (crushed head) used by Santamour (1965 b).

These observations suggested that chemical substances associated with the insect cuticle might be involved in resin crystallization.

CHEMICAL-INDUCED CRYSTALLIZATION

Both quinones and o-dihydroxypolyphenols have been shown to be normal components of the cuticle of beetles (Wigglesworth 1947, Hackman *et al* 1948). Chemical tests showed the presence of both types of compounds in the insects under study.

Quinones may react with certain resin acids in at least two ways. Some quinones (e. g., benzquinone) give normal Diels-Alder addition prod-

ucts (Weinhaus and Sandermann, 1936; Ruzicka and Kaufmann, 1941). Resin acids may also undergo a photo-sensitized oxidation to form peroxides (Moore and Lawrence, 1958; Schuller *et al*, 1960; Schuller and Lawrence, 1961). The unique structural feature of all sensitizing dyes used in the oxidation reaction was the o-quino-noid grouping.

Thus, not only are quinones and o-dihydroxypolyphenols normal components of insect cuticle, but they may also react with several of the resin acids. Therefore it seemed pertinent to test certain of these compounds in the crystallization reaction.

The chemicals selected for testing included p-benzoquinone, o-dihydroxybenzoic acid (protocatechuic acid), o-dihydroxyphenylacetic acid, and the dye, Eosin Y. These compounds were used dry or in water, glycerine, or alphapinene solution. The test material was stirred into resin droplets on glass slides and the slides were incubated at 37°C. Briefly to summarize the results, none of the compounds would crystallize fresh resin less than a few hours old but all were successful in causing crystallization of day-old reactive resin. The further exploration of chemical-induced crystallization is suggested as a course for more intensive study.

CRYSTALLIZATION INHIBITORS

The crystallization of resin under natural conditions may be retarded by some resin acids or other natural compounds. Hampton (1956) found that a small quantity of a new resin acid (caribeic) was sufficient to retard crystallization of slash pine wood resin. The presence of elliotinoic acid (5 percent) and the aldehyde elliotinol (5 percent) in resin of the same species was also effective in retarding crystallization (Ray V. Lawrence, personal communication). Could it be that the lack of crystallization in cortical resin of *P. Griffithii* is partly caused by the high proportion of dehydroabietic acid?

DISCUSSION

It should be obvious from the foregoing that more research is needed. The major drawback to rapid progress in the resin-pest field has been that few persons wanted to tackle this complex problem. Chemists, entomologists, and geneticists all have had enough problems of their own without stepping outside their respective disciplines. Recently, however, interested scientists have acquired the equipment, skills, and cooperation needed for critical studies. The work of the entomologists — Smith, on terpenes; Yates, on resin crystallization — is indicative of the future of research dealing with resins and pest resistance.

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The Sixth Barnes Lecture

The sixth in the annual series of Laura L. Barnes Lectures on Botany and Horticulture will be given on Thursday, April 18, 1968. The speaker will be the distinguished Director of the New York Botanical Garden, Dr. William C. Steere, who will deliver an illustrated lecture on "Plants of the Tundra."

Dr. Steere has spent many years studying the mosses, as well as the flowering plants, of high

arctic latitudes and is an acknowledged authority on the flora of this inhospitable but fascinating part of the world.

The lecture will take place at 8:30 P.M. in the auditorium of the Penn Valley School at Righter's Mill Road and Hagy's Ford Road in Penn Valley, Pa. Associates and their friends are cordially invited to attend.

A Note on *Adina rubella*

JOHN M. FOGG, JR.

In November 1961, the Morris Arboretum received a package of living plants from Mrs. A. M. Freeman, Jr., of Noriton, Connecticut. Since the donor had informed us that all of these plants should be considered as somewhat tender, we placed them on a protected south-facing slope in the company of various other species which are regarded as not completely winter-hardy in this area.

Although several of the plants in this lot have since died, e.g., *Loropetalum chinense*, *Escallonia virgata*, and *Carissa foetida*, a specimen of *Adina rubella* has flourished and is now a robust shrub about five feet tall. It flowered for the first time in late summer 1964 and has bloomed every year since. Its globular clusters of whitish flowers are reminiscent of the inflorescences of the button-bush, *Cephalanthus occidentalis*, to which it is related.



Fig. 65. *Adina rubella*.

In his Arboretum Activities notes in this Bulletin for September 1967 (page 50), Dr. Dahl called attention to several rare or unusual plants which were in flower in the Arboretum in mid-September. Among them was *Adina rubella*.

In attempting to find additional information concerning this shrub, I was surprised to discover that it was not even mentioned in such standard horticultural volumes as Bailey's "Cyclopedia of Horticulture" or his "Manual of Cultivated Plants," "Hortus II," Rehder's "Manual of Cultivated Trees and Shrubs," Bean's "Trees and Shrubs Hardy in the British Isles," Krüssman's "Handbuch der Laubgehölze," Schneider's "Handbuch der Laubholzkunde," Wyman's "Shrubs and Vines for American Gardens" or Zucker's recently published "Flowering Shrubs."

The only work consulted in which this species is included is the "New Illustrated Encyclopedia of Gardening," edited by T. H. Everett of the New York Botanical Garden and published in 1960. Here the plant is characterized as an "unusual fragrant-flowered shrub, hardy in sheltered places as far north as New York City."

Adina is a member of the Rubiaceae or Madder Family; and, according to Dalla Torre and Harms (*Genera Siphonogamarum*), includes 10 species native to tropical Asia and subtropical Africa. *A. rubella* was described from China by Hance in the Journal of Botany, Vol. 6:114, 1868. It is a much-branched shrub with opposite, ovate, lustrous leaves, strongly suggesting those of certain species of *Abelia*, of the Caprifoliaceae. Although the plant is not evergreen, the foliage is retained on the branches until late autumn or early winter, making it an attractive subject at a season when most deciduous shrubs have shed their leaves.

The flowers, as already mentioned, are densely crowded in globular or spherical heads at the ends of slender branchlets. The photograph reproduced here was taken from a herbarium specimen collected in August 1965 in the Calloway Gardens at Pine Mountain, Georgia.

This attractive, little-known, late-flowering shrub, apparently quite hardy here, should prove of interest to gardeners in the Philadelphia area.

Arboretum Activities

(Continued from Page 74)

oldest example of *Sassafras* that gives vivid demonstration of the interesting bark configuration of the mature tree.

With no desire to emphasize catastrophe, I report that Mr. DeMarco and colleagues have made excellent progress in making accommodation for these emergency circumstances which include the substantial flood damage to the fence along Stenton Avenue. It is of interest that the portions of the fence escaping injury from flood waters some three feet deep were the sections anchored by ingenious lead lugs devised by a previous Director, Dr. J. R. Schramm. Obviously in making the present repairs, we have followed Dr. Schramm's excellent plan.

Plant portraits for November in the Arboretum should certainly include: the brilliant Winterberry (*Ilex verticillata* (L.) Gray), of which selected forms are available; *Ilex opaca* Ait. cultivar "Arden" and for striking contrast, the yellow-fruited American Holly (*I. opaca xanthocarpa* Rehd.) and the dark-red-fruited *Ilex Forrestii* Comber from eastern Tibet. The true tea of commerce (*Cauellia siuensis* (L.) Ktze.) with its individually charming white blossoms adds interest to the late garden as is the case with *Osmunda armatus* Diels. Cherry blossoms in late November are to be seen on reasonably close examination of the mature specimen of *Prunus subhirtella* Miq. var. *autumnalis* Mak.

THE STAFF

On 4 October Dr. Fogg gave a talk on "The Search for New Drug Plants" to The Country Gardeners at Lima, Pa. He was the principal speaker at the annual banquet of The Men's Garden Club of Delaware Valley on 25 October where he delivered an illustrated lecture on "Some Gardens of Ireland and the British Isles."

At the Sixteenth International Horticultural Congress held in Brussels in 1962, the Morris Arboretum was designated as the International Registration Authority for Cultivar Names in

Magnolia under the direction of Dr. Fogg. At present Dr. Fogg is devoting a considerable portion of his time to the preparation of a list of such names for early publication.

For four years Dr. Fogg has served as Editor of the Newsletter of the American Magnolia Society, of which organization he is president. He functioned as guest Editor of the October issue of the Arboretum and Botanical Garden Bulletin which was devoted to the herbaria of the member institutions. He is currently preparing a series of articles on "Bonsai and Botany" which will appear in "Bonsai," the Journal of the American Bonsai Society.

In collaboration with Dr. Li, Dr. J. J. Willaman as Research Associate is preparing an extensive compilation of alkaloid-yielding plants as described in the literature of the period 1957-68. An earlier report, based on the literature through 1957, was published by Dr. Willaman in Technical Bulletin 1234 of the U. S. Department of Agriculture. The current study indicates that the number of alkaloid plants for the current decade is approximately equivalent to the number reported during the previous 150 years.

On 13 November, Dr. Allison presented an invitation lecture on "Fungi, People and Ideas" at the Wilmington Art Center.

Mr. Keyser has made very significant progress with the difficult task of transplanting valuable specimens from our nursery areas to permanent locations or to the lath house.

Dr. Dahl spent the first week of November at the Ames Research Center where the interesting preliminary results of the research projects that were on board Biosatellite B, together with progress reports on future flights, were intensively reviewed. On 10 November, Dr. Dahl presented a lecture on "Palynology" to the University students registered in Geology 205 (Paleontology).

A. ORVILLE DAHL

Fred W. Schwoebel

The following essay, reprinted from the "Pennsylvania Beekeepers' Newsletter" for August, 1967 is a brief but most fitting tribute to the late Mr. Fred W. Schwoebel who served so admirably as Curator of the Langstroth Bee Garden.

Pennsylvania apiculture lost one of its most scholarly and distinguished members with the recent death of Fred W. Schwoebel, Curator of the Bee Garden, Morris Arboretum of the University of Pennsylvania. He recently had suffered a severe stroke and, although he was making progress toward recovery at the end of several weeks, he ultimately succumbed.

For at least 25 years, Fred kept bees on the Morris estate which eventually became the Morris Arboretum. In 1951, the Arboretum established a bee garden and this naturally became the site of Fred's apiary. The "Morris Arboretum Bulletin" of September 1962, in an account of the dedication ceremonies for the Langstroth Bee Garden, states: "To Mr. Fred W. Schwoebel, well known Philadelphia beekeeper and student of hive life, particular acknowledgment is due. It is to him that the Arboretum is indebted for the suggestion that the Bee Garden might ap-

propriately be constituted a memorial to Lorenzo Lorraine Langstroth, at the same time calling attention to 1951 as the centennial year of Langstroth's most memorable discoveries. It is indeed fortunate for the Arboretum that Mr. Schwoebel, who for some years has maintained stands of bees in the Arboretum, has consented to act as Curator of the newly established garden."

During his tenure as Curator, he discovered and studied the value of the well-known "bee-bee" tree or *Evodia Daniellii*, as a source of nectar in late summer dearth periods. He propagated the plants and sent seeds and plants all over the world. Well-known to many for his knowledge of beekeeping and botany, he acted as host for groups on the occasion of picnics and visits to the Arboretum. His extensive knowledge and accommodating nature will be remembered by all who knew him. He continued as Curator until his death.

Library Accessions

The following are among the items added to the Library during 1967:

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*All about Begonias. B. Brilmayer. Doubleday & Co. Garden City. 1960.
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- ***Plant Cover of Sweden. Acta Phytographica Suecica. 1965.
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* Gift of Dr. E. T. Wherry
** Gift of the publisher
*** Gift of Dr. A. H. Brown
**** Gift of Dr. J. M. Fogg, Jr.
***** Gift of Mrs. E. G. Thomas

New Associates

The Arboretum is happy to welcome the following new Associates who have been enrolled since September 1967:

Mrs. Windsor F. Cousins
Mrs. Norman R. Cusworth
Mr. Brook D. Gutman
Mrs. Rae T. Lowenburg
Mr. Franklin Osgood

Mr. William S. Patten
Mrs. George W. Scheetz
Mrs. T. A. Sharp
Mrs. Helen M. Winslow

Associates' Corner

A LITTLE LEARNING

"A little learning is a dangerous thing," writes Alexander Pope. But sometimes I wonder. To be sure the Sorcerer's Apprentice got into plenty of trouble with his smattering of chemistry. But sciences are different. He should have chosen one of the Natural Sciences to experiment with. He would have been safer taking a walk in the woods than opening valves and turning wheels in his master's lab. And we don't know much about this master. He may have been a stern and haughty man, demanding more of his pupil than he could possibly do or understand. I believe there is no such person in the Natural Sciences. Take botany. I know a whole arboretumful of people and not one of them is proud. They are humble in their learning, and generous, and they do not expect too much of beginners—even of perpetual beginners.

A scholarly man was helping me identify a swamp grass that I had found. I said sadly that it seemed a pity to spend so much time over one grass when I didn't know any of the others. "Not at all," said he. "Learn one, and sometime you will learn another."

I have found that to be good advice. Learn one. Learn it well. Take time to establish it in your mind and in your affections. As soon as possible go back to where you found it and see it again in its natural habitat. Visit it at all seasons of the year.

"And sometime you will learn another." By some miracle you do, and then perhaps a third. By this time you have acquired an inkling of what "plant relationships" are all about. "Genus" and "species," words formerly to be avoided, become illuminated guideposts along a dark and difficult path. "Families" take you a step further and add to the excitement. Discovery of the close relationship between beautiful golden club, that lights up dark pools in the cedar swamps, and skunk cabbage comes as a shock, but the resemblance is obvious once you've seen it. On the other hand you find that the tiny, rare twin-flower, well-hidden in a New Hampshire forest, is

nothing but a kind of honeysuckle! Probably the reason for that relationship will remain a mystery to you for years or forever. So be it.

Beyond families come "orders," "classes," and "divisions"—vistas down which one may look now and then to see the great framework of the whole, but along which one does not have to walk.

With a little learning, each acquisition comes fraught with personal interest. That *Cypripedium* was the one that caused an argument with a friend. The friend proved to be right, and the *Cypripedium* is nailed down in memory. *Narthecium* grew in a bog into which a companion fell, up to her shoulders. *Narthecium* will never be forgotten.

Finally, there is something to be said for the Unknown. The stars in the Milky Way, most of whose names we will never know, are just as much a part of the splendor of the night sky as Orion and the Great Dipper. Furthermore on a soft spring day in the Pine Barrens, it is easy to miss the woods for (trying to identify) the trees. Then on the shore, those intriguing sandpipers feeding at the edge of the waves—we can spend quite a long time trying to distinguish the least from the semi-palmated (Are those legs "yellowish" or "greenish" or "blackish" or "greenish-black"?") but there comes a moment when we do not care which is which, because we are lost in watching the incredibly swift movements of the tiny legs as they run after the edge of a wave, and the sudden lifting of the whole crowd in flight with sunshine on their wings.

To learn one new plant in a day or a year, one new stone, one new star, is like throwing open windows and doors in a long-closed house. The air that comes in is fresh, and the view shows many roads leading off into the distance. How far we go along those roads is no great matter. The point is that with a very little learning (Alexander Pope to the contrary) each step can be a delight.

PHOEBE CROSBY

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Errata

- p. 27 right, line 1, for Oak read Cork
- p. 28 right, line 21, for topics read tropics
- p. 43 after first No. 7 for lateral read lateral
- p. 43 after second No. 8 read Leaflets lanceolate, evenly serrulate with teeth about 1 mm. deep.
- p. 54 line 2 for cover read color
- p. 64 left, line 10, for nursery-men read nurserymen
- p. 64 left, line 38, for Yulani read Yulania
- p. 64 right, line 20 after Santamour insert (6)
- p. 64 right, line 26, for accent read account
- p. 65 Fig. 56 inverted
- p. 66 right, line 14, after Washington delete period
- p. 68 right, line 16, delete equal sign
- p. 68 right, line 22, for sub-genus read subgenus
- p. 69 right, insert numbers 1-7 before each entry under Literature Cited